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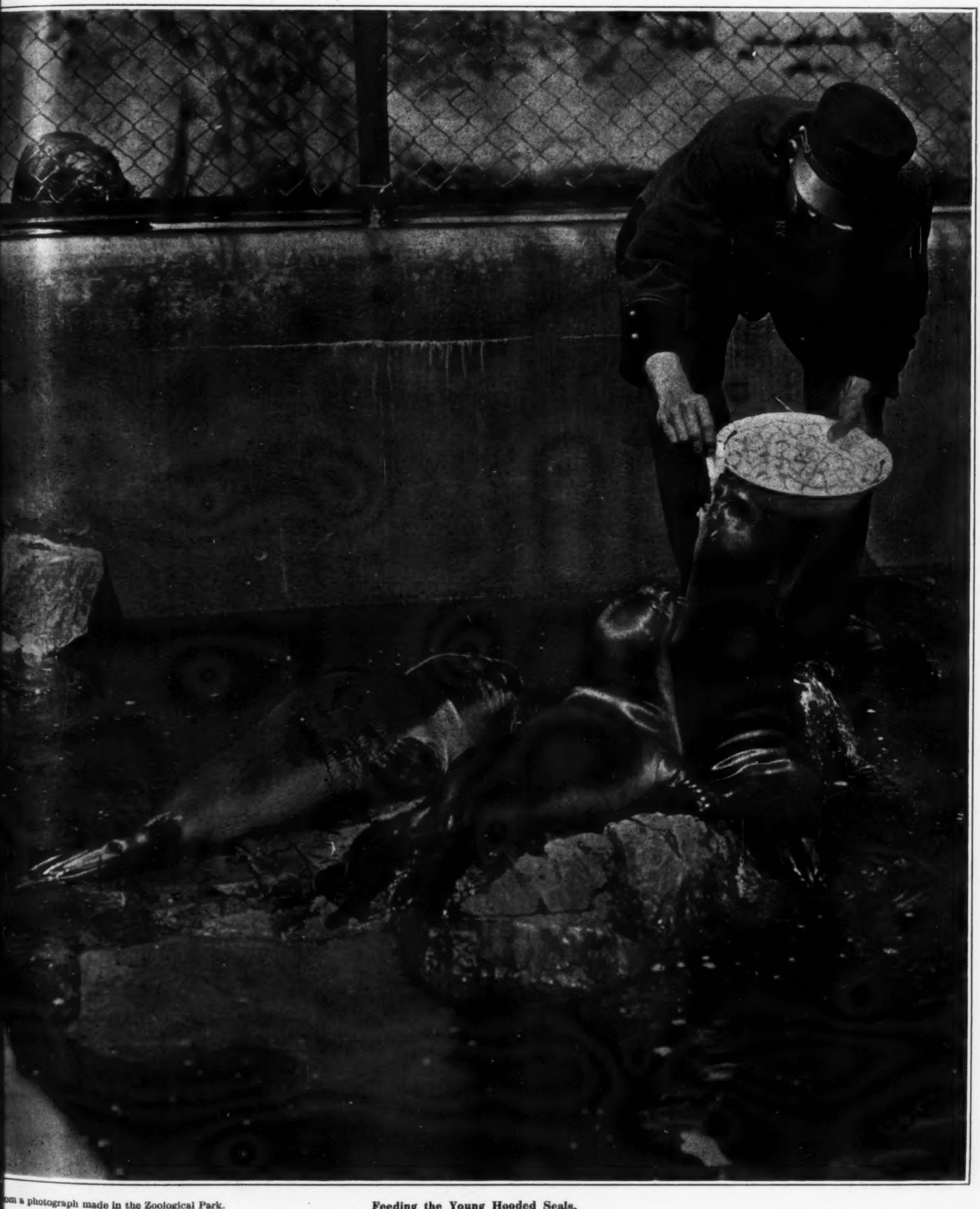

[Fr]om a photograph made in the Zoological Park.

Feeding the Young Hooded Seals.

THE HOODED SEAL OF THE NORTH ATLANTIC—[See page 120.]

A Review of the Physics of Light—I*

Prof. Silvanus P. Thompson's Presidential Address at the Recent Optical Convention in London

INTRODUCTORY.

SEVEN years have elapsed since the first Optical Convention assembled, in 1905, under the presidency of Dr. Richard T. Glazebrook. Both that gathering and the second one, in which we are now met, witness to the efforts which are being made, not less by those concerned in the industries than by scientific men, to promote the progress of optical science and of optical trade. Like all other industries which depend on the application of scientific discoveries, the optical industry has felt the pressure of the times; and a widespread sense of need that science and manufacture must be associated in an alliance more intimate and more active than heretofore has been the moving cause of both conventions.

We are met here to exchange views, to deliberate, to discuss; to learn, from one another and from the material objects which we have been able to bring together in our optical exhibition, anything and everything which can stimulate our thought, widen our information, or concentrate and harmonize our activities in matters optical.

DEVELOPMENT.

Seven years is but a brief span in the development of any industry, or in the history of any science. It may well be that in the seven years which have fled since our first Convention we have no obvious great discovery to chronicle. When the telescope was invented, at the beginning of the seventeenth century, the fame of it, and of the discovery by Galileo of the satellites of Jupiter, ran round all Europe. When in 1815 the kaleidoscope—a mere toy—was produced, 300,000 were sold within six months. When in 1838 the stereoscope astonished the world, half a million were sold in half a decade. When in 1896 Röntgen described his X-rays, the whole scientific world was filled with wonder. Certainly no such sensational novelty as any of these has appeared during the last seven years, though the developments of the kinematograph have drawn from the public a thousand times as much money as any of the inventions or discoveries just named did in their respective eras. But if no optical invention of first magnitude nor discovery of fundamental importance has been announced, it must not be assumed that there have been no advances. Progress there has been—progress solid and real all along the line. No branch of physical science can in the present day remain stationary. The workers are too numerous; the rewards of success, whether in the joy of scientific discovery, or in fame, or wealth, are too alluring to permit stagnation. Moreover, the increase of knowledge, the mastery of principles over phenomena, the conquest of the forces of Nature, are cumulative. Every attempt at wider generalizations, even if unsuccessful in itself, provokes new researches, and extends the foundations for further advance. To this truth the science of optics furnishes no exception. Progress is continuous, even though the workaday world hears little of it, and heeds it not. For the true pioneer halts not to listen for the sound of the plaudits; he toils on, content in the faith that some day he, or those after him for whom his labor will avail, will arrive at the goal.

The history of the development of optics presents many notable features. Combining, as it does, the practice of a highly-skilled craft, in the construction of instruments, with the exercise of refined and elaborate theory, it affords continually recurring proofs of the truth that practical applications and abstract science, so far from being antagonistic, afford to one another the most powerful support and stimulus. Probably no other branch of physics—not even magnetism, with all its mysteries—has had a greater effect in stirring the scientific imagination. The very phenomena appeal to the eye, as do those of no other science, by their beauty and intrinsic charm, and the variety of them has taxed the strongest powers of analysis to devise consistent theories for their explanation. Newton might declare *hypotheses non fingo;* but that renunciation on his part has not prevailed with others to abandon tentative theorizing. The history of optics is scarred with the battles of rival theories, of which the end is not yet determined. It may, indeed, almost be taken as axiomatic that in all efforts to reach the unknown, to advance human knowledge, it is better to set before one's self some directive hypothesis than to work aimlessly. Every great pioneer in physical science has to frame conjectures, and to keep them, as it were, in a state of solution until either confirmed or disproven. He may even have half a dozen rival and mutually destructive hypotheses before him as he works. Truth is not infrequently reached by a process of exhaustion, by honestly following clues that ultimately prove false, since when they are proved to be false the path to truth has been more closely delimited than before. Even positive error in theory has been known to lead to new and valuable results; as when Euler, arguing from the false premiss that the human eye is achromatic, deduced the conclusion that it must, therefore, be possible to construct by optical means a lens that should be achromatic. Of the theories of light now in vogue, something must indeed presently be said, but it is perhaps more important here to point out how very far it is possible to push the study of optical phenomena and laws, without committing one's self to any theory at all[1] as to the vexed question of the physical nature of light itself.

ABSTRACT METHODS AND THEORIES.

To gain a clearer perception of the meaning of those numerical and geometrical laws which govern the phenomena of light, it is certainly permissible, and on occasion highly useful, to consider these relations apart from the concrete physics involved. Little advance would have been made in any of the exact sciences had not the relations of number and form been studied in the abstract sciences of algebra and geometry. There has been a distinct gain in separating the study of the geometry of position from the geometry of motion, and further, in separating kinematics, the science of pure motion, from kinetics, the science of forces producing motion. In like manner in that part of optics which is concerned only with the directions in which light is propagated—namely, geometrical optics—there is distinct advantage in laying aside all considerations as to the physical nature both of light itself and of the media through which it is propagated, so gaining freedom from the embarrassment of conflicting hypotheses.

No doubt there is, even here, room for rival theories. The old hypothesis of Plato, of Euclid, and of Empedocles, that light consisted of visual rays, which proceeded from the eyes to the objects viewed, is no longer admissible; but it is not in itself inconsistent with the geometrical laws admitted to be true.

The mediæval hypothesis, apparently originating with Pythagoras, that light consists of corpuscles shot out from shining bodies and traveling in straight lines, subject to reflection and refraction on their way to the eye, is equally inadmissible, but equally consistent with the geometrical laws. The kindred theory that light consists of rays—a theory still in being, so far as language is concerned—is little more than an admission of the observed fact of the rectilinear propagation of light, and if the use of the word "ray" is not taken to imply any physical hypothesis as to the nature of light itself, is a step toward that clarity of treatment which has just been advocated. The wave theory of light, adumbrated by Leonardo da Vinci and by Hooke, but first shaped by Huygens, and triumphantly established by Young and Fresnel, may equally claim to be regarded as a kinematics of light, provided the use of the term "wave" is not held to import any preconceived notion as to the physical nature of light waves themselves. It is certainly difficult to think of waves in the abstract, unless they are waves of something—some medium capable of executing and conveying undulations—but their geometrical properties as to direction, and as to all those phenomena, both of Nature and of optical instruments, which depend on direction, may be studied in absolute independence of any physical constitution, whether mechanical or electro-magnetic, that may be assigned to them. It was Huygens who, by repeatedly insisting that a "ray" of light was merely the path traveled by the "wave," was able to clarify thought, and initiate a new departure. In themselves the terms "ray" and "wave" are both kinematical terms, and both are generally deemed to imply physical concepts. If we were forced to choose between them, it is the term "ray" that must be abandoned and as connoting a physical hypothesis contradicted by the facts of diffraction. On the other hand, the term "wave" may be adopted without assigning to it any other than a purely kinematic significance. Moreover, it is just as possible to build up a purely geometrical optics on the conception of wave motion as on that of ray motion; and Huygens's definition of ray reconciles the two. In this connection it is significant to remark that Prof. Schuster, though in the preface to his "Theory of Optics" he deprecates, as a retrogression, the substitution of equations representing mathematical conceptions for mechanical or electro-magnetic theories; nevertheless, himself introduces at an early stage a kinematical discussion, leading him to say that "a wave-front is best defined as a surface such that the disturbance over it originally came from the same source, and started from that source at the same time," thus carefully removing from the definition any implication as to its physical nature.

GEOMETRICAL OPTICS.

In fact, whether founded physically on the notion of the projected corpuscle, the ray, or the wave, geometrical optics, that section of the science which deals solely with the directions of the light paths (either free in space or as controlled by some optical instrument), necessarily deals with geometrical conceptions and expresses itself in geometrical terms. Without returning to the primitive work of Alhazen on Reflection, we owe to Kepler first, and to Descartes, Barrow, Cotes, Euler and Lagrange[2] afterwards, the formulation of the laws of geometrical optics, as relating to lenses, mirrors, telescopes, and microscopes. The simple formulæ that every student knows so well for the determination of the position of the principal focus, for conjugate foci, and for the magnification of the image by the lens, mirror, or telescope, have come down from them, though more familiar to us in the forms used by Coddington or Parkinson and the current university text-book. Unconsciously we have become accustomed to think of them, and more particularly the expressions relating to the passage of light through lenses, as essentially optical formulæ, and as having something to do either with the glass of the lenses to which they are applied, or with the properties of light. The fact that they are usually derived trigonometrically, by assuming certain simplifications such as that the angles of incidence and emergence, or those of the pencils of rays, are small (so small that sines and tangents may be written simply as angles), or that the lenses themselves are infinitely thin, gives a certain arbitrariness to them, while the mixing up of the mono-chromatic or so-called "spherical" aberrations, which are a purely geometric affair, with the chromatic aberrations that arise from the physics of the glass, tends to further confusion. The first stage toward deliverance from this is due to Gauss, who, in 1840, in his "Dioptrische Untersuchungen," laid the foundations of a new treatment. With rare insight he succeeded in reducing the performance of any optical combination of centered lenses—aberrations apart—to a geometrical system of "principal" and "focal" points and "principal" and "focal" planes, whereby the formulæ for lenses of any thickness, and for instruments compounded of several lenses, became as simple as those formerly employed for the formation of images by a single infinitely thin lens. Independently, Moebius had, in 1830, discovered the same properties of the "principal" points, though he missed a part of their significance for determining the refracted rays. They had, indeed, been foreshadowed by Harris in 1775. To the system of cardinal points and planes of Gauss, Listing in 1845 added the "nodal" points, which coincide with the "principal" points of Gauss only if the first and last media of the lens-system are alike (both air). Toepler, in 1870 added the "negative principal points" (or "symmetric" points[3]), and indicated the existence of a series of image-planes, lying beyond one another at distances apart equal to the focal length, in which planes the linear magnification has values of successive whole numbers. Blakesley, in his suggestive little book on Geometrical Optics (1903) has extended this conception.

While the method of Gauss gave a clear and consistent account of the generalized optical system in producing images, the very simplicity of the method depended on assumptions unrealizable in practice for simple lenses, viz., that the images should be free from the aberrations of distortion and curvature, as well as from those which result in indistinct definition. It was therefore an artificial and highly abstract method of treating lens problems of great power for its own purpose, but incapable of dealing with the phenomena of

* Delivered June 19th, 1912.

[1] It was in this spirit that in 1849 Lord Kelvin framed his Mathematical Theory of Magnetism, in which he strove to free the subject from all hypotheses as to the nature of magnetism itself, and so to reach a more general view than Poisson had obtained.

[2] Lagrange succeeded in solving the problem of the passage of rays through a system of successive lenses by finding expressions in the form of continued fractions, which, though cumbrous, can be solved by sufficient labor.

[3] In passing I may remark on the extreme convenience in graphical construction of one property of the two symmetric planes—namely, that if any oblique ray passes through one of the planes, through a point having co-ordinates y, z in that plane, it will on emergence from the optical system pass though a corresponding and conjugate point $-y, -z$ in the other symmetric plane. I made use of this property in a mechanical model which illustrates the finding of conjugate points of a lens-system. The Focometer, which I described to the Royal Society in 1891, depends on the use of the symmetric planes.

abberration. In the hands of Martin, Gavarret, Reusch, Helmholtz, Gariel, and Pendlebury, it received various enlargements, including extension to the formation of images by curved mirrors. Later Casorati and his distinguished pupil, Galileo Ferraris, developed Gauss's method by use of determinants. Ferraris's treatise was translated into German and found wide acceptance on the Continent.

But earlier than any of these expounders of Gauss's method, Maxwell, in 1858, published in the *Quarterly Journal of Mathematics*, a short but pregnant paper, which has remained all too little known to English physicists, comprising investigations intended to show "how simple and how general the theory of optical instruments may be rendered by considering the optical effects of the entire instrument without examining the mechanism by which these effects are obtained." He assumed that a "perfect" instrument would fulfil the three conditions of freedom of astigmatism, curvature, and distortion. On these assumptions he established, with elegant simplicity and economy of symbols, a theory, geometrically complete, of the formation of images; while he revenged himself upon his own simplicity by conclusively proving that no instrument, depending on reflection or refraction, could possibly be "perfect"—that is, free from the aforesaid aberrations—except the plane mirror![4]

But British optical science needed not to wait upon Gauss for the revelation of a method. Embedded in the notes in the second volume of Robert Smith's ponderous "Compleat System of Opticks," of 1728, there stands (pages 76 to 78) a delightful digression, setting forth a "noble and beautiful theorem," which he states to have been "the last invention of that great mathematician, Mr. Cotes, just before his death at the age of thirty-two, upon which occasion, I am told, Sir Isaac Newton said, 'If Mr. Cotes had lived we might have known something.'" This theorem, which is too elaborate to quote at length, is an elegant solution of the proposition how to find the situation and apparent magnitude with which an object is seen through any number of lenses of any sort, at any distances from each other and from the eye and the object. Of this general proposition many cases were worked out by Huygens and others. But the beauty of Cotes's demonstration was overlooked.[5] One of Huygens's particular cases, communicated to the Royal Society, in 1669, is worthy of being quoted—namely, that if an eye looking at an object through a lens sees the image of apparently a certain size at a certain distance, it will still seem to be of the same size and distance if the places of the eye and the object are interchanged. Cotes demonstrated this still to be true for an optical system of several lenses. Another particular case of the theorem is known as Helmholtz's tangent law of magnification.

In 1893 there appeared a book destined to produce a profound impression on the study of optics, Czapski's "Theorie der Optischen Instrumente nache Abbe." Of the originality and power of Abbe's teaching, and of the ability with which his follower expounded his views, there can be no question. Alas! that both the distinguished master and his accomplished pupil are no longer with us. One of the many notable features[6] of that book is the chapter on the "Formation of Images." It dawned on Abbe, more fully than on Gauss, Moebius, or even Maxwell, that the true theory of the formation of images is not only independent of the particular optical mechanism of instruments, but is, in fact, purely a question of projective geometry. Let all space be divided into two regions (which may or many not overlap), one containing the object, the other containing its image. For the formation of the perfect image it is required that the image shall correspond with the object, point for point, line for line, plane for plane. This implies that to every point in the object space there shall correspond a conjugate point in the image space, in such wise that to all points ranged on any line in the object there shall be formed points correspondingly ranged on a corresponding line in the image space. This correspondence, termed by Moebius a "collinear relation," is a purely geometrical question, to be treated by methods familiar to the student of such works as Cremona's "Projective Geometry," or Salmon's "Analytic Geometry."[7] The best account in English of Abbe's theory is to be found in Southall's recently published "Principles and Methods of Geometrical Optics," a work invaluable to every teacher. By Abbe's intuition, that the formation of images is a pure question of the geometry of rays, that is of straight lines, without any ascription of optical properties or any question whatever of physical ways and means, he completed the last step in that clarification alluded to at the outset. It may, perhaps, perplex old-fashioned devotees of optics to learn that principal foci are simply the vanishing points of anharmonic ranges; that conjugate foci on the principal axis are homographically related, or that foci in general are points such that conjugate lines meeting in them cut orthogonally. These phrases seem to fill the air with their sweet jargoning; nevertheless, they express abstract relations which every student of optics ought to know. For if this collinear relation is realized in the performance of any instrument, it will at least be free from the defects of curvature of image and distortion. But freedom of the image from curvature and distortion can scarcely be said to have a definite meaning unless the optical system of the instrument is, at least approximately, so constructed that points of the object are rendered with good definition literally as points in the image. Mr. Gordon has given us the useful term *anti-point*, to denote the image, whether well-defined or blurred, of a point-object. But unless the anti-point be itself a well-defined point, what avails collinearity? The perfect optical instrument, lens, mirror, or combined system, must not only be collinear, but stigmatic. Correspondence of image to object, point for point, line for line, plane for plane, is the ideal sought. Want of collinearity results, as said, in two defects, called "curvature" and "distortion;" the image of a flat object being formed not as a plane, but as a curved surface, and unequally magnified at the margins as compared with the central parts—defects particularly obnoxious in photographic lenses. But there are also defects in the definition of focus, which are no less serious, and are known as aberrations. Given freedom from aberrations and fulfilment of collinear relations, then everything is reduced, even in the most complicated system of centered lenses, to the sweet simplicity of Gauss,[8] wherein distances of foci, both principal and conjugate, are measured from the respective equivalent planes. Before, however, we enter upon aberrations in detail, we must deal with the work of two of the giants of past days.

To be continued.

[4] See also Klein. "Zeitschrift für Math. u. Phys." xlvi., 376, 1901; or Whittaker, "The Theory of Optical Instruments," 1907.

[5] Apparently after Smith's time this was forgotten until, in 1886, Lord Rayleigh drew attention to it. It is now to be found in the recent text-books of R. A. Herman, M. von Rohr, J. P. Southall, and others.

[6] Another is the thorough consideration of the effects of limiting the rays in an optical instrument by diaphragms and stops, a matter developed in the more recent writings of Dr. M. von Rohr.

[7] The latest contribution to the question of abstract collinear relations is the "Elemente der Projektiven Dioptrik," by Prof. Arthur von Oettingen, Leipzig. 1909.

[8] One system of geometrical optics forms an exception. It is that of Biot (1844) and of Bosscha (1877-86), who base their equations on measurements of the distances of object and image not from equivalent planes, but from the respective refracting surfaces, and introduce into their expressions the angular magnitude as seen from the pupil of the eye and four constants—viz., two principal focal lengths, also measured from the first and last refracting surfaces respectively, and two ocular points which are the conjugates of the summits of the refracting surfaces. Sissingh has adopted this plan of measurement, but its advantages are doubtful.

The New Star in Gemini*

The Spectroscope Reveals High Temperature and Pressure

By Otto Hoffman

Again one of those enigmatical stars which Tycho Brahe regarded as new creations has appeared in the sky, and again it was an amateur astronomer that first detected the new member of the stellar host.

On March 12th, 1912, as Sigurd Enebo, at Dombaas in Norway, was observing a variable star in Taurus, he perceived a hitherto unknown star in the neighboring constellation of Gemini, in a region which he had observed four days previously without detecting any questionable object. The new star is situated about two degrees south of Theta Geminorum, and not far from the point where Turner discovered a new star in 1903. Both of these Novæ confirm the rule that new stars are generally found in or very near the Milky Way.

Nova Geminorum 1912 immediately attracted the attention of many astronomers. The early observations were facilitated by moonless nights and, in England, by the coal strike, which in many places eliminated the disturbing illumination from gas lamps as well as the smoke of factories.

Enebo estimated the magnitude of the new star at 4.3 on March 12th and 4.2 on March 13th. Other observers estimated it at 3.5 on March 14th. Thereafter the brightness declined, with some fluctuations, to the seventh magnitude on April 19th, since which date it has declined slowly but steadily.

At observatories which possessed photographs of that part of the sky, the plates were carefully examined for traces of the new star. On a plate made at Heidelberg on March 7th, Prof. Wolf found a star of the twelfth magnitude in the position of Nova Geminorum 1912, and a star of the fifteenth magnitude was found in the same position on a plate made in 1909.

*Abridged from *Prometheus* for the Scientific American Supplement.

In color the new star resembles other Novæ, which are usually described as red or reddish-yellow. The English observer, Phillips, describes Nova Geminorum 1912 as one of the reddest stars he has ever seen. On March 22nd Guthnick observed a diminution of 0.4 magnitude in brightness and a coincident diminution in redness. On March 24th Stroemgren estimated the

color as bluish, but at the end of the month the star had regained its intense scarlet hue.

In accordance with the fluctuations in brightness and color, many changes in the star's spectrum have been observed. In general, the spectral peculiarities resemble those exhibited by Nova Aurigae in 1892 and Nova Persei in 1901. In each case a continuous spectrum is crossed by broad bright hydrogen lines and by dark absorption bands. From the observed displacements of the lines some observers infer the presence of matter moving with enormous velocity, indicating a cataclysmic origin of the new star. Schwartzschild estimates this velocity at 540 kilometers (336 miles) per second on March 15th and 350 kilometers (217 miles) per second on March 17th. Still greater velocities are computed by other observers.

The photographs made by Harny and Millochau in Paris show a continuous spectrum extending to λ 315, indicating an exceedingly high temperature. These observers attribute the broadening and displacement of the spectral lines to intense pressure in the atmosphere of the new star. All of this agrees with Seeliger's hypothesis that Novæ are produced by collisions between stars and nebulæ composed of gas or dust.

In addition to the lines of hydrogen, the spectrum shows calcium, helium and iron lines, and also the nebula lines, which are believed to be due to an unknown element. The extensive series of spectroscopic observations made by Inigues in Madrid, between March 16th and April 16th, show several great variations, of which the most striking is the almost total effacement of the calcium line on March 20th. After March 25th a gradual decrease in the general brightness of the spectrum was observed.

Prof. Max Wolf has discovered periodic variations in the hydrogen lines of the new star, indicating a shifting of the point of maximum brightness alternately toward the red and toward the violet end of the spectrum. The period of oscillation appears to be 7 or 14 days. The variations in the new star's apparent magnitude also follow a period of 7 days, according to Kritzinger's observations.

The Metric System in Europe.—With the adoption by Denmark of the metric system on April 1st of this year, there remain only three European nations who do not seem to be inclined to accept this system. They are Great Britain, Russia, and Montenegro.—*Das Echo.*

The New Illumination on the Place de la Concorde, Paris.

High-Pressure Incandescent Gas Lighting

A Very Efficient and Economical System

By the Paris Correspondent of the SCIENTIFIC AMERICAN

THE new high-pressure system of incandescent gas lighting is being introduced for street illumination in Paris and in other French cities, and, judging from the present indications, it appears likely that the method will find increasing application in the future. After having given the system a trial on a small scale, the municipality of Paris has now installed it in several of the main streets and boulevards. The Paris Correspondent of the SCIENTIFIC AMERICAN may speak from personal observation in stating that the new light is incomparably superior to the ordinary street lamp, and high-pressure lights mounted upon high poles give an illumination closely resembling that of an arc lamp, the effect being altogether very pleasing.

Among French cities which are giving the system a trial may be mentioned Marseilles and Bordeaux.

With the ordinary system the only means of obtaining a high candle-power is to use a large number of burners in one lamp. Instead of this the new method uses an increased pressure, either for the air or for the gas. For example, in the compressed gas system, the burner takes in air at ordinary pressure, while the gas comes from the burner through special piping from high-pressure mains connected to a compressor at the gas plant. If, on the other hand, the compressed air method is used, a similar compressor delivers air to special mains which run parallel with the gas mains. In this case the gas is fed at ordinary pressure. In either case, a very much larger amount of gas can be burned in a burner of given size, and a correspondingly high candle power is thus assured, the effect being comparable with that of an arc light. Not only is great concentration of light thus secured, but the method is also very economical, as the gas and air can be mixed in just the right proportions to give the best conditions for high luminosity. Not only this, but a thorough mixing of the gas and air can be insured. These facts together tend for the highest possible economy.

As regards the form of the burners, the reverse type is employed, one to three such burners being placed in each lamp. In some cases it is not desirable to use a lamp of very high candle power, as this will not give the most favorable distribution of light. In practice, a 1,000 to 1,500 candle-power lamp is best for city lighting, and in such cases the lamp should be raised from 15 to 20 feet above the street level.

The lamps as used in Paris are built of strong sheet iron, enameled at a high temperature, as this is found best to withstand the wear and tear of use. The lighting and extinguishing of the lamps is effected by means of an automatic valve controlled by the pressure in the mains, so that the mere starting or stopping of the compressor causes the lamps to light or go out, as the case may be. The lamps can, however, of course also be turned off by hand, so that one or more individual lamps can be cut out, if the occasion arises. The compressor is small and compact, and is preferably run from a small electric motor mounted on the same base. The regulator maintains a constant pressure in the mains. The number of lamps in use does not in any way affect the pressure, and there is no need of a cumbrous gas or air holder.

One form of lamp is hung from a curved bracket and can be raised and lowered, much in the same way as an arc lamp. The pulley can be lodged inside the large base of the lamp and the cord run up through the pole, or, if preferred, a simpler arrangement can be employed, in which the pulley and cord are on the outside. The gas and air supply are in such case fed through flexible tubing, which are so arranged as to avoid undue wear.

Needless to say, lamps may be suspended from brackets on the sides of houses or from wires run across the street.

As regard the height, the following recommendations are made: For 1,000 candle-power, 18 feet; 1,500 candle-power, 22 feet; 4,000 to 4,500 candle-power, 25 feet.

On the Place de la Concorde, in Paris, a rather fine example of the new type of lighting can be seen. The poles are ornamental in character and the globes are of clear glass. Our illustration shows something of the effect which is thus produced. Between the new lamps are arranged lamps of the old type, which are used for the late hours of the night.

The following figures show the comparative cost of electric lighting, ordinary gas lighting and the high-pressure system. It will be seen that the result is favorable to the new method. The prices represent the cost in Paris, and must be modified according to local conditions. The estimate is based on the cost of 5,000 candle-power in each case, with the price of gas at 11 cents per cubic foot and the cost of electric current at 14 cents per kilowatt-hour. Time of lighting, 1,000 hours.

Incandescent light.—With metallic filament lamps of 16 candle-power taking 1.25 watts per candle, we have 16×1.25 watts $\times313$ (this number of lamps being needed to give 5,000 candle-power) $=6.26$ kilowatts, and this at 14 cents, amounts to 87.5 cents per hour, or per 1,000 hours, $875.

Arc light.—In practice, we assume that 500 candle-power take 500 watts per arc. For 5,000 candle-power we need $5{,}000 \div 500=10$ arc lamps of 500 watts, or 5,000 watts, or 5 kilowatt-hours; 5 kilowatt-hours $\times14$ cents $=70$ cents per hour or for 1,000 hours the cost is $700.

Incandescent gas lighting with ordinary lamps.—To obtain 5,000 candle-power with such lamps giving 90 candle-power for 3.85 cubic feet per hour gas consumption there are needed 56 burners, and 56×3.85 cubic feet $=216$ cubic feet. This at 11 cents per cubic foot gives 24 cents per hour or for 1,000 hours the cost is $240.

Lighting with the new "Pharos" lamps.—The lamps consume 0.018 cubic feet of gas per candle. For 5,000 candle-power we need $5{,}000\times0.018=90$ cubic feet. This at 11 cents per cubic foot $=10$ cents per hour. For 1,000 hours this figures $100. The compressor plant costs little, and for a 10,000 candle-power plant a 1/4 horse-power motor is used and this at under load, taking 0.2 kilowatts per hour. The cost at 6 cents per kilowatt-hour is thus 0.012 cent per hour for the motor, or $12 1,000 hours. Total for the "Pharos" lamp, $100 + $12=$112.

Compared with arc lamps, the upkeep is very much less by the new gas system, as the lamps only require cleaning every two or three weeks. As compared with ordinary incandescent gas lighting there is also a good economy. There are no glass chimneys to be replaced and the number of mantles to be replaced is much less.

The new departure in Paris represents another step in a long series of revolutionary stages through which the art of street lighting has passed, from various extremely primitive and crude devices, which to us now would seem rather to accentuate the darkness and dinginess of the streets of the ancient cities, to the modern principal thoroughfare of a great city, illuminated at times almost more profusely at night than by day, not so much through the light sources regularly provided by the city, as by various lamps and illuminated signs and windows of stores and other establishments. It would indeed be interesting to follow up in some detail the history of this development. In this, as in most other branches of industry, it would be found that within comparatively recent times there has been a sudden evolution, after the art had remained more or less stagnant for many centuries before. Our resources at the present day have become so multiplied that we have not one nor two, but many highly efficient and entirely distinct methods of which we can avail ourselves. For the small town and suburbs, the ordinary gas jet still finds extended application, though it has very largely given place by now to the much more efficient incandescent mantle. The tungsten lamp is used with much success. Of the electric arc lamp we have several types, which give excellent service, among them the flaming arc, with its almost too intense glare. We all remember the time when, ushered in by the new developments in the manufacture of calcium carbide, acetylene lighting excited our admiration by its beautiful white flame. It is true that, except for special purposes, this has not found as extensive application as was at one time anticipated. And so on, the list might be prolonged almost indefinitely, ringing the changes through the mercury vapor lamp, the Moore light, and others of less consequence; and in such enumeration last, but not least, we should refer once more to the high-pressure incandescent gas light.

The Manufacture and Application of Nitrous Oxide—II

By A. S. Neumark

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HISTORY OF NITROUS OXIDE INHALATION.

SIR Humphry Davy, the famous English physicist and chemist, brought nitrous oxide into general notice in 1799, and it was he who discovered and made known those peculiar and remarkable properties which earned for it the name of "laughing gas." In a letter dated April 10th, 1799, and sent to his friend D. Gilbert, Sir Davy said in part: ". . . I have found a mode of obtaining pure gaseous oxide of azote, and breathed to-day in the presence of Dr. Beddoes and some others 16 quarts of it for nearly 7 minutes. It appeared to support life longer than even oxygen gas and absolutely intoxicated me. Pure oxygen gas produced no alteration in my pulse, nor any other material effect, whereas this gas raised my pulse upward of twenty strokes, made me dance about the laboratory as a madman, and has kept my spirits in a glow ever since. . . ."

Had he inhaled more of the gas, complete insensibility would have followed. However, Sir Humphry Davy seemed to have realized this, for he says in his researches: "As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." Unfortunately he became interested in other medical problems, and therefore did not take advantage of his discovery. While thus Davy must be given credit for suggesting the use of nitrous oxide in surgery, it was an American dentist of Hartford, Conn., Dr. Horace Wells, who first practically applied this gas for painless surgery. The incident which suggested to Dr. Wells the use of nitrous oxide as an anesthetic is thus described by T. Smith in "An Inquiry Into the Origin of Modern Anesthesia" (1867): On the eve of December 10th, 1844, Horace Wells (a native of Vermont, who had made Hartford his home) attended a chemical lecture by G. Q. Colton, during which he administered to Dr. Wells, S. A. Conley and other persons, nitrous oxide gas. Mr. Conley, on being brought under its influence, became unusually excited, and taking the floor, performed sundry evolutions thereon, during which he contused and abraded both of his shins pretty extensively, by collision with the benches, which fact was noticed by Dr. Wells. On recovering his self possession, the doctor inquired of him whether he felt any pain from the injuries received. He replied that he was not conscious of having sustained any injury, but on pulling up his pantaloons, blood appeared in profusion. Wells immediately turned to a friend sitting by and expressed the belief that a man could by inhaling the gas, render himself so insensible, that he could have a tooth extracted without pain. Next day he asked Dr. Colton to bring a bag of gas to his dental office, as he wanted a tooth pulled. The gas was duly administered, while Dr. Riggs extracted the molar. On recovering, Wells exclaimed: "This is the greatest discovery ever made; I did not feel it so much as the prick of a pin." This was the first operation performed in modern anesthesia, and was the forerunner of all other anesthetics. The discovery was for a time overlooked during the excitement created by the discovery of the anesthetic property of ether. However, it was not forgotten; in 1863, nitrous oxide was reintroduced as an anesthetic by Dr. Colton, who with other prominent dentists opened an office in New York for the extraction of teeth. Prior to this, Dr. Colton had removed, within three weeks, 3,000 teeth from the mouths of the citizens of New Haven. In a letter sent to Prof. Henry M. Lyman, dated March 14th, 1881, Dr. Colton writes: "We recommended the use of nitrous oxide on the 15th of July, 1863, and on the 4th of the following February we began to take the autograph signatures of all our patients on a scroll, numbering them on the margin. The present scroll number is 121,709. We have never had a fatal case or serious ill effects from the gas."

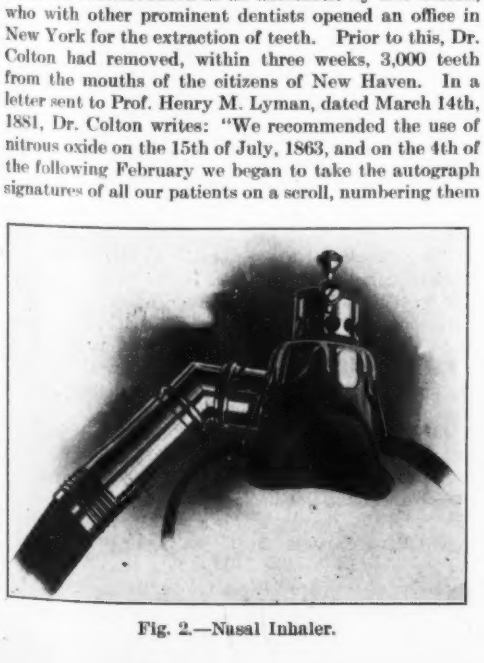


Fig. 2.—Nasal Inhaler.

PHYSIOLOGICAL EFFECTS OF N_2O INHALATION.

If pure nitrous oxide is inhaled, without air or oxygen, it produces sleep, continued it causes anesthesia and finally asphyxia. At the commencement of inhalation there is a slight feeling of suffocation, which however quickly passes away; then follows a pleasurable sensation and a feeling of exhilaration. In former times, when the gas was inhaled solely to produce intoxicating effects for purposes of amusement or of physiological experiments, the administration of N_2O was discovered after the first stage of inhalation. This stimulant stage if uninterrupted, rapidly merges into the second or narcotic and anodyne stage. A tingling sensation is felt in the whole body, particularly in the extremities and on the tongue, and a buzzing in the ears The brain seems to swim in dizzy and ever swifter gyrations. Respiration becomes rapid, owing to insufficient oxygenation, short and shallow; the pulse becomes full, hard, regular and slow, and later irregular and small. Consciousness is lost in a whirl of confused and incoherent ideas and impressions, and the narcosis deepens into the beginning of the third or true anesthetic stage. A more or less complete asphyxia are the final symptoms, produced by undiluted nitrous oxide. In the early days of N_2O administration, the effects produced by the gas were unsatisfactory, owing partly to impurities, and owing to the excitement caused by the admixture of air.

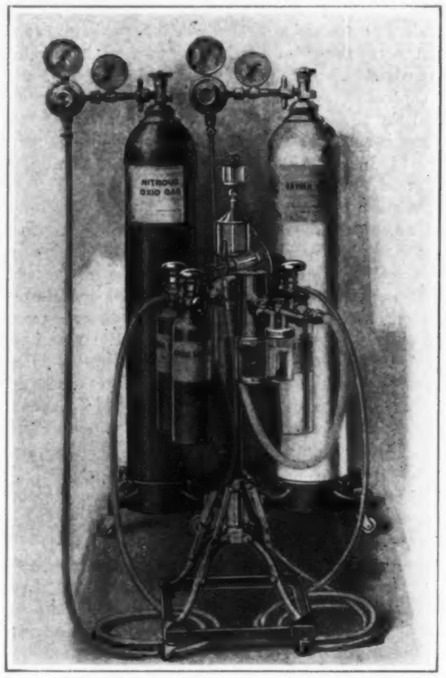


Fig. 1.—General View of Nitrous Oxide-oxygen Apparatus.

When apparatus were introduced with an arrangement that excluded air, a more perfect anesthesia was attained. Secondary or after-effects, such as sick headache, mental depression, nausea or emesis, very infrequently arise from its use. Dr. Müller states that nitrous oxide affects colored races more rapidly then the white, and women are more easily affected than men. The average time to anesthetize a patient with this gas is from 50 to 100 seconds, narcosis lasting from 30 to 60 seconds; the amount of gas required to produce satisfactory anesthesia in an adult is from 5 to 6 gallons.

Nitrous oxide supports combustion in the presence of air, but it does not support life. When administered, it enters the blood by diffusion through the thin walls of the air cells of the lungs. It is mechanically absorbed by the blood, without forming a true solution, and without affecting its hemoglobine, and is carried throughout the system. Paul Bert found that 100 volumes of blood absorb 45 volumes of gas when anesthesia is complete.

Winterstein who studied the part played by the oxygen during anesthesia found that by inhaling nitrous oxide, the process of oxidation is checked. It is able to displace oxygen, but whatever union takes place is very unstable, as the blood parts with the nitrous oxide at once when brought in contact with oxygen or air. Nitrous oxide is, as we see, not only an anesthetic, but is an asphyxiant as well, since it excludes the oxygen from the blood. If the latter quality is removed, nitrous oxide forms an ideal anesthetic, as it is non-toxic, and there is no other agent capable of producing narcosis with so little disturbance.

ANESTHESIA BY NITROUS OXIDE AND OXYGEN IN COMBINATION.

Attempts had been made more than 40 years ago to find a method by which the gas may be introduced into the air passage without cutting off the supply of oxygen. Dr. Andrews of Chicago is said to have been the first (1868) to use a combination of nitrous oxide and oxygen. Paul Bert of Paris (1879) experimented with a mixture containing 80 per cent N_2O and 20 per cent oxygen and reported that complete anesthesia could readily be accomplished by this combination. By administering pure oxygen continuously with nitrous oxide, sufficient oxygen can be supplied to the organism to carry on oxidation, so that the vital functions are not impaired. An average of about 12 per cent of oxygen is necessary for a continuous administration. In this way all fear of asphyxia is eliminated, and the return of consciousness is not accompanied by any after-effects. Inhalation of nitrous oxide alone has been said to produce its effect simply by asphyxiation; but there can be no doubt that this gas has true anesthetic properties. Its use in combination with oxygen certainly demonstrates this, as asphyxia is entirely avoided, and perfect anesthesia can be obtained.

PROLONGED ANESTHESIA.

Prolonged anesthesia by means of nitrous oxide and oxygen has been introduced within recent years. The French physician, Paul Bert, was first to consider N_2O as an anesthetic for prolonged surgical work. In a paper read on November 11th, 1878, before the Academy of Sciences, Paris, he suggested a method of increasing the length of anesthesia by administering nitrous oxide under pressure. Owing to the cumbersome and costly apparatus required, his suggestion was never put to practical use. While anesthesia produced by pure N_2O lasts but 30 to 60 seconds, it can be prolonged indefinitely by admixture of oxygen. Anesthesia is produced solely by nitrous oxide, the office of the oxygen being merely that of a modifier of the effects of the former, eliminating all of its unpleasant features. The N_2O+O combination can be employed for many major surgical operations, and it may be inhaled for a greater length of time than any of the other general anesthetics. Dr. C. K. Jeter of Cleveland, O., reported a case in which a patient had been under the influence of the combined gases without a breath of air for 2 hours and 48 minutes. Nearly 600 gallons of N_2O and 80 gallons of oxygen were used. After completion of the operation, and withdrawal of the anesthetic, the patient regained all of her mental faculties within 1 minute. Nausea and other post-anesthetic complications were entirely absent.

In the beginning of the narcosis, pure nitrous oxide is usually administered, and after anesthetization is obtained, oxygen is added gradually in proportions of 6 to 12 per cent. The advantages of nitrous oxide—oxygen anesthesia, according to Dr. Haggard, are: quickness of action; absence of uncomfortable sensations to the patient; almost immediate recovery; absence of lung complications; danger to kidneys, and post-anesthetic vomiting and improbability of subsequent degeneration of the kidneys, liver and heart. Its disadvantages are: that it is not suitable for corpulent, plethoric and alcoholic patients, that its zone of anesthesia lies within narrow limits, that it requires an accomplished anesthetist, that it is not always easily obtainable and that the cost is high.

The ideal anesthetic has as yet to be found; but of all anesthetics known and used, the N_2O+O mixture seems to be the safest. It has been stated that fully 750,000 people annually inhale N_2O in this country. Statistics have shown that but 17 deaths (from 1860 to 1900) have been directly traceable to N_2O while no death has been

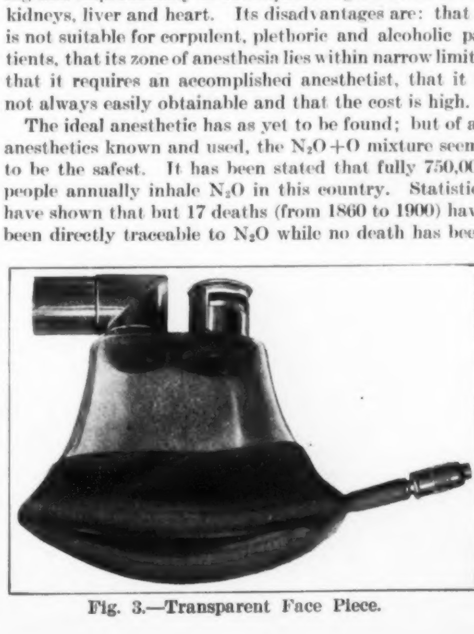


Fig. 3.—Transparent Face Piece.

reported from gas and oxygen narcosis. Ream of Chicago reports 30,000 administrations without one single accident; Jeter reports 17,716 administrations (a large number being for major surgical operations, lasting from ½ to 4 hours) without a death. Compared with these figures, the mortality of ether administration covering 407,533 cases is 16,302; for chloroform it is one in 3,162 cases. To cite Dr. Jeter: "Where the general health is impaired from wasting diseases, abnormal growths, degenerate changes, etc., 'gas and oxygen' is the anesthetic par excellence and leaves nothing more to be desired." It certainly is by far the best and safest anesthetic for the dental surgeon; 870,000 extracting specialists have administered it without an accident.

Nitrous oxide and oxygen administration should be employed in all cases in which chloroform and ether are contra-indicated. Its more general use by the surgeon should be encouraged. The complicated apparatus, the great skill and difficulty in administering the combined gases—all necessary, and seldom obtainable in most hospitals, have hitherto precluded its general use. Nitrous oxide has in recent years also been used in connection with ether for major surgery. Anesthesia is induced by N_2O and insensibility is then maintained by the use of ether vapors. By this means the initial stage of excitement, which sometimes follows the commencement of ether inhalation is avoided, as is the inconvenience to the patient due to the disagreeable odor of ether. The time necessary for the production of anesthesia is considerably shortened, and thus the requisite quantity of ether lessened. By using warm vapors of "gas and oxygen," the absorbtion by the blood is increased, the bodily heat is conserved and anesthesia made still safer, as has been demonstrated by Dr. Gwathmey in 1905. While this holds good for any general anesthetic, nitrous oxide is more in need of warming, as it is extremely cold when passing from the liquid to the gaseous state.

APPARATUS USED FOR ADMINISTERING NITROUS OXIDE.

Dr. Hillischer of Vienna first introduced suitable apparatus for administering gas and oxygen (1886). Satisfactory apparatus have later been devised by Hewitt, Martin, Wood, Cunningham, Jeter and others. Hewitt of London introduced the most perfect working apparatus, the principle of all others being nearly the same. Lack of space forbids my going into a detailed description of the working methods of the various apparatus. A clear conception of their construction may be readily obtained by examining the accompanying illustration (see figure 1). The apparatus used for administering pure N_2O simply consists of one or two cylinders of liquid gas, the orifice of the valve being provided with yoke connection and a wheel key is usually employed to operate the valve. From the cylinder the gas enters a gas bag (sometimes replaced by a gas-holder) and from there it passes to the inhaler. In the apparatus used for administering "gas and oxygen," the gases from the cylinders also enter a soft rubber bag, which serve as a pressure regulator, and then pass to a mixing chamber. In the Hewitt apparatus the proportions of N_2O and O are controlled by a movable index. When thoroughly mixed the gases are conveyed to the inhaler. A vapor warmer is usually attached in front of the mixing chamber; it is filled with water, kept hot by a small alcohol lamp and thus conveys the vapors to the patient at a temperature of from 85 to 90 deg. Fahr. The inhalers used are either face pieces, when covering mouth and nose; mouth pieces when inserted between the lips, or nasal inhalers (Fig. 2) when held before the nose or inserted into the nostrils. The latter are employed for dental surgery or operations in the mouth and throat. Next to pure gas a properly constructed inhaler is one of the most important adjuncts for the administration of the gases. It must be perfectly airtight in its fittings, as any admixture of air will either very much delay or wholly prevent the desired results. The face pieces have a celluloid hood (Fig. 3) to give the operator a full view of the patient's lips and features. The whole apparatus should always be tested before using and all tubes examined for leaks. The oxygen, after anesthesia (or analgesia) with N_2O, is admitted gradually, and the flow of this gas must then be constantly watched; signs of cyanosis indicate the administration of more oxygen, evidence of excitement and returning consciousness, less oxygen. Some patients require much more oxygen than others and some only very little of it. It is of the utmost importance to secure a steady and even flow of both gases. The writer thinks it rather surprising that not more use is made of pressure regulators and reducing valves in the construction of apparatus. The stop cock of the N_2O cylinder should be kept warm with the aid of a rag soaked in hot water, as the cold produced when N_2O passes into the gaseous state often causes clogging of the orifice by solidifying.

Aside of its use as an anesthetic, nitrous oxide is sometimes used in combination with oxygen or air for certain disorders. Mixtures of these gases compressed into tanks have been paraded by quacks as "compound oxygen." Inhalation of oxygen containing 20 to 40 per cent of N_2O is said to be beneficial in nervous prostration, insomnia, hysteria, melancholia and asthma. Nitrous oxide, aside of being a nerve stimulant, has also slight tonic and diuretic properties and may be taken in aqueous solution. Since N_2O produces intense cold when passing from the liquid to the gaseous state, it may also be employed (like ethyl-chloride) as a local anesthetic, by allowing a spray of the liquid gas to play on the part to be operated on.

OTHER APPLICATIONS OF NITROUS OXIDE.

But few technical uses have been found for nitrous oxide, this being chiefly due to the high cost of the gas ($2 per 100 gallons). Dentists sometimes use it instead of oxygen in combination with hydrogen or illuminating gas in their blowpipes for soldering platinum parts to crowns of artificial teeth. It has also been recommended in the manufacture of linseed oil. Nitrous oxide being an endothermic compound, its use has been recommended in the manufacture of explosives. Pictet's "Fulgurit" contains N_2O in combination with easily combustible liquids, such as ether or alcohol. If a method could be devised whereby the gas could be manufactured at much lower cost, there is no doubt that other technical applications could be found for it.

Testing and Judging Kinematograph Films*

THE great development of the kinematograph industry in France and the excellence of French films are largely due to the application of systematic tests, which are very often neglected in Germany and other countries.

Most of the celluloid films used in ordinary photography are sliced or planed from celluloid blocks and are consequently hard and dry from the beginning. Kinematograph films, on the contrary, are made by pouring a celluloid solution upon a moving base in a continuously operating machine, and they acquire the necessary solidity by a process of slow drying.

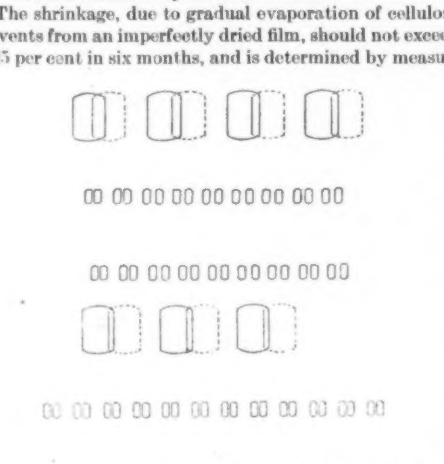
If this process is not carried far enough the film continues to dry and shrink during use and soon becomes torn and worthless. Undried or imperfectly dried films made by this method also show a tendency to curl toward the "dry" side (i. e., the side which is not in contact with the temporary base) in the machine. Such films do not lie flat in the gate of the projecting lantern and their curvature produces distortion in the picture and causes the film to wear out more rapidly. Sensitized kinematograph films are sometimes injured by electric sparks produced by reeling the film too tightly in a moist condition or in a damp atmosphere.

What are the requirements which should be satisfied by a good kinematograph film? In the first place, the film should be both flexible and hard enough to be used for 1,000 to 1,500 projections. The gelatine coating should remain firmly attached to the celluloid without having its photographic properties affected by the latter even after long keeping. The celluloid foundation should not change in form or dimensions, in the dry or wet state, the film should show no dust or other impurities under 200-fold magnification, and its surface should not be easily affected by scratches or other mechanical injuries.

The photographic emulsion of a negative film should be very sensitive and free from fog. The latter quality is likewise necessary in the positive film, which should be capable of yielding fine-grained black pictures, rich in contrast.

The testing should include, in the first place, the dimensions of the film. The total thickness, inclusive of the emulsion, should be from 0.11 to 0.16 millimeter (0.004 to 0.006 inch), the width 34.8 to 35.0 millimeters (1.37 to 1.38 inch). The height of the picture was fixed at either 3/4 or 4/5 the width, by the International Congress held in Paris in 1900. Hence the height of the picture should be about 18 millimeters (0.7 inch) and its width 24 millimeters (0.95 inch), leaving 5.5 millimeters (0.22 inch) for the perforations on each side. The interval between consecutive pictures is 1 millimeter (0.04 inch). Accuracy in the width of the film is particularly important, because too wide a film will stick in the gate, the width of which is 35.1 millimeter (1.382 inch), or will pass through it by jerks, while too narrow a film will produce unsteadiness by latteral oscillations.

The shrinkage, due to gradual evaporation of cellulose solvents from an imperfectly dried film, should not exceed 1.25 per cent in six months, and is determined by measuring the length of a strip of film at regular intervals during that period. Another cause of variation in the length of a gelatine-coated film, in the moist state, is found in the hygroscopic properties of the gelatine and also of the foundation when the latter has been subjected to a process of saponification for the purpose of making the coating adhere firmly. The foundation itself, especially if it is composed of acetyl-cellulose, is not always waterproof. The amount of stretching due to these causes is determined by attaching a weight of 200 grammes (about 7 ounces) to one end of a strip of film and suspending the strip by the other end in water. The increase produced by six hours' immersion should not exceed 1.25 per cent.



Tests of Kinematograph Films for Regularity of Perforation. The Upper Diagram Indicates Poor, the Lower One Good Perforation.

Other changes caused by water are studied by soaking the film and carefully examining it. In addition to celluloid and acetyl-cellulose, various other substances, including viscose, formyl-cellulose and hardened gelatine, are sometimes employed as the material of film foundations. As these films are not waterproof they are coated, on both sides, with celluloid or acetyl-cellulose, but water can still be absorbed at the unprotected edges and perforations, causing swelling and deformation.

The tensile strength and extensibility of a film are measured by the usual methods. The strength ranges from 5 to 7 kilogrammes per square millimeter (7,000 to 10,000 pounds per square inch) for a film 0.1 millimeter (0.004 inch) thick. The extensibility varies from 10 to 15 per cent. The flexibility is measured by a machine which bends the film in opposite directions alternately.

The film should also be tested in the conditions of practical use. For this purpose an endless band of film is run through the kinematograph at a known speed for a measured interval of time, so that the number of times it has passed through the machine can be computed. A good celluloid film should suffer little damage from 1,000 or 1,500 passages.

The gelatine coating of a good kinematographic film adheres so firmly that it cannot be detached, even partially, by pinching, pulling or rubbing.

The inflammability is tested by exposing a motionless film, in the gate of the kinematograph, to the rays of the projecting lantern. If the film is blank it should not be affected except when the point of the conical beam strikes it, and even then only a pin-hole should be burned through it. A motionless pictured film melts in the gate, but it should not take fire.

The most important condition for perfect projection is absolute accuracy in perforation, which brings each picture precisely to the same place in the gate. Each side of each picture has four perforations, 2.6 millimeters (0.103 inch) wide, 1.7 millimeter (0.067 inch) high, and 4.75 millimeter (0.187 inch) apart. The distance between corresponding perforations, and consequently between the centers, of successive pictures should be carefully measured. The normal distance is 19 millimeters (0.784 inch) but all projecting machines will work with a distance of 18.75 millimeters (0.738 inch). In order to allow for shrinking the distance is actually made a little greater (19.05 to 19.1 millimeters) in positive films.

This important distance can be measured to 0.1 millimeter by means of a millimeter scale, provided with a vernier, and can be determined, less accurately, by measuring, with an ordinary rule, the distance between the upper edges of the first and forty-first perforations, and dividing the result by 10.

The regularity of the perforation is also essential for flawless projection. It is tested by laying one end of the film on the other and seeing if the perforations coincide throughout the length tested, which should be as great as possible. A more accurate test can be made with the aid of a special apparatus, in which enlarged images of the perforations overlap, more or less uniformly, as the accompanying diagram indicates.

Films are tested, in the factory, for fog, electric effects and dust, by developing and projecting specimens taken before and after perforation. The uniformity of the sensitive coating and its freedom from air bubbles are determined by developing to a grey tone a purposely fogged film. Scratches in the coating or the foundation are revealed by similar tests. The sensitiveness and gradation of tone are determined in the usual way with the sensitometer and photometer.

* Adapted from Dr. Gustav Bonwitt in *Zeitschrift fuer angewandte Chemie.*

The Measurement of Velocities

A Survey of Various Devices Used

By E. Hoeltje

It is possible for a skilled observer with a sharp ear to estimate the time of a foot race or similar event to 1/5 second by counting the ticks of an ordinary watch. Usually, however, the measurement is made by means of a stop-watch. The large dial of the stop-watch is provided with a third and very long hand, which accomplishes one revolution in a minute, and each of the sixty spaces of the circumference is subdivided into five parts, each of which represents 1/5 second. The place of the second hand of an ordinary watch is here occupied by a minute hand, which indicates the number of revolutions of the large pointer. By pressing a button the hands can be stopped at any instant. The complete measurement of an interval of time requires the button to be pressed three times. The first pressure releases the hands, the second stops them, the third brings the long second hand back to the figure 12 and the hand of the small dial to the figure 60, leaving them in readiness for a new measurement.

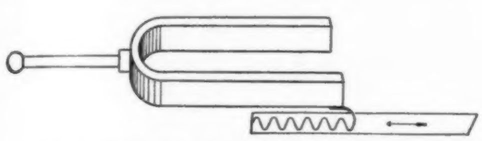


Fig. 1.—Tuning Fork Tracing Its Vibrations.

In astronomical and other work much more exact measurement of time is required. Intervals of time can be measured to 1/100 second by means of a moving band of paper in which a small puncture is made by clock-work at the beginning of each second. The minutes are noted by omitting the first puncture of each. The instant of any event is recorded by pressing a button which closes the circuit of an electro-magnet and thus causes a needle to perforate the paper at a point between two of the punctures which indicate seconds. By measuring with an accurate rule, the distance of this perforation from the preceding and following punctures which indicate seconds, the time of duration can be determined to 1/100 second.

Still greater precision can be obtained by employing a tuning fork whose rate of vibration is accurately known (Fig. 1). A fine needle attached to one prong of the tuning fork presses a moving band of paper, covered with lampblack, and traces a sinuous line. The epoch of any observed event is recorded by an electrically operated needle, as in the apparatus first described.

An apparatus for recording the speed of railway trains is illustrated in Figs. 2 and 3. On down grades, in approaching stations, and in some other situations there is a prescribed limit of speed which must not be exceeded. On the other hand, an engine-driver is often tempted to utilize a down grade to make up lost time. For the purpose of detecting such infractions of the rules a series of mercury contacts which close electric circuits on the passage of a train, are established at several points, A, B, C, D, placed at accurately measured distances along the track (Fig. 3). The weight of the train depresses the bolt B (Fig. 2), the upper end of which presses against the bottom of the rail, while its lower end rests on the flexible cover M, of a vessel filled with mercury. The mercury is thereby partially expelled from the vessel through the tube R into the small vessel T, in which hangs a fork G, insulated from the vessel. When the mercury touches the fork, metallic connection is established between G and T, closing a circuit containing the battery E and the electro-magnet H. A writing point attached to the armature of the magnet is thus pressed against a band of paper which is moved uniformly by clock-work and which contains a series of perforations corresponding to half minutes (Fig. 3). Thus, as the first wheel of the train passes over the points A, B, C, and D, the dots x, y, z, and u are made on the moving paper band. Each millimeter of the band corresponds to 5 seconds in time, and thus with the aid of the perforations the speed employed in traversing each of the stretches A B, B C, and C D can be determined. If, for example, the distance x y on the paper is one centimeter and the distance A B is 600 meters, the time of transit is 50 seconds and the mean speed is 12 meters per second or 43.2 kilometers per hour. The object of dividing the distance A D into three parts is to prevent the attainment of excessive speed through even a small distance. It may be asked how the engine-driver can judge the speed he is making. Experienced drivers do this unconsciously, but novices are compelled to measure the speed by the watch. This they can do in daylight by timing the passage of the kilometer stones placed along the track, and at night by counting the jolts caused by passing over rail junctions. If, for example, these jolts occur at intervals of one second with rails known to be 12 meters long, the speed is 12 meters per second, or 43.2 kilometers per hour. Or the number of revolutions made by the driving wheel in a measured interval of time can be observed, and multiplied by the known circumference of the wheel. The number of revolutions can be obtained in daylight by direct observation of the wheel, and at night by counting the puffs of the engine and allowing two or four puffs to each revolution, according to the type of locomotive employed.

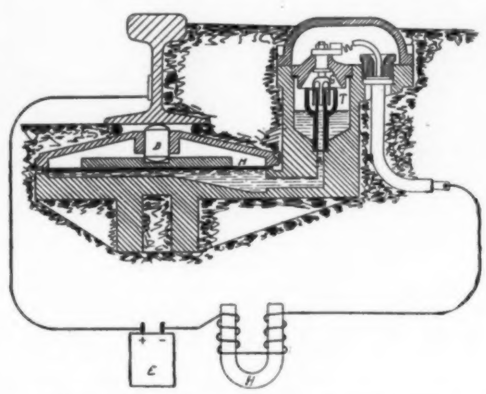


Fig. 2.—Device for Measuring Railway Speeds.

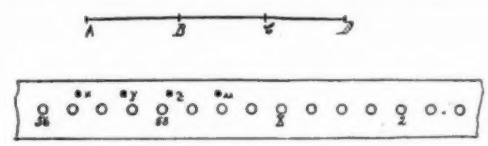


Fig. 3.—Stations and Record (See Fig. 2).

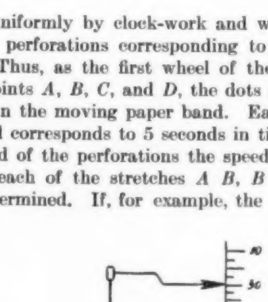


Fig. 4.—Float Speed Recorder.

Automatic speed indicators have also been devised for use on locomotives. In one of these devices a vessel containing liquid is attached to a vertical shaft connected with the engine (Fig. 4). The surface of a rotating mass of liquid assumes the form of a paraboloid N B C, and the depression of the middle point B increases with the speed of rotation. Hence, a pointer connected with a float can be so arranged as to indicate the number of revolutions by its passage over a graduated scale. Apparatus of this sort, however, is better suited for stationary than for locomotive engines. A device which is less sensitive to shock is indicated in Fig. 5. Oil or glycerine is drawn by the small pump P from the vessel B and is forced through the pipe D into the air chamber W, from which it flows back slowly into B through a fine nozzle at the end of the pipe L. The more rapidly the pump, which is operated by the driving shaft, works, the higher is the air pressure in the chamber W. The air chamber contains a manometer, from which the number of revolutions per minute can be read directly.

Another group of speed recorders is based upon the well known principle of the centrifugal governor (Fig. 6). A rotating vertical shaft W carries two arms, terminating in heavy balls K K, which diverge from the vertical by an angle which increases with the velocity of rotation. As the arms diverge they move the sleeve M upward against the pressure of the spiral spring F, the upper end of which presses against the fixed collar B. As the sleeve rises, a pointer Z, connected with it, moves over a scale graduated to give the velocity of rotation directly.

Electricity has also been brought into service for the measurement of velocity, as Fig. 7 shows. In this device a rotating shaft W carries a permanent horseshoe magnet M between the poles of which is placed an aluminium ring A attached to an independent shaft X. The rotation of the magnet M induces eddy currents in the ring A and produces an electro-magnetic torque which increases with the velocity of rotation, and which is opposed by a spiral spring. In obedience to these opposing forces the ring and its shaft are turned through an angle depending upon the velocity and a pointer Z, attached to the shaft X, indicates directly on a graduated scale, the number of revolutions per minute.

*Translated for the Scientific American Supplement from Die Umschau.

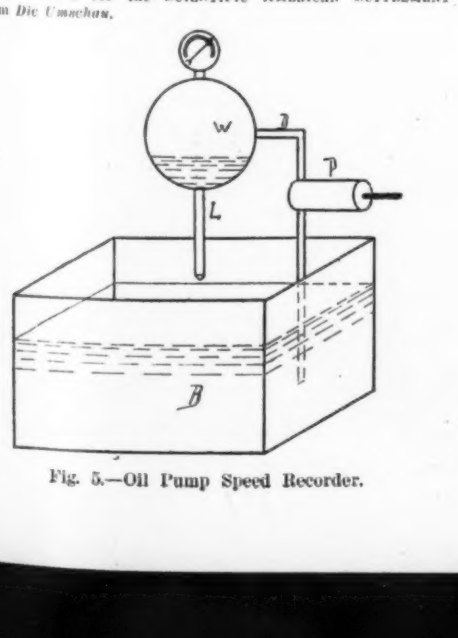


Fig. 5.—Oil Pump Speed Recorder.

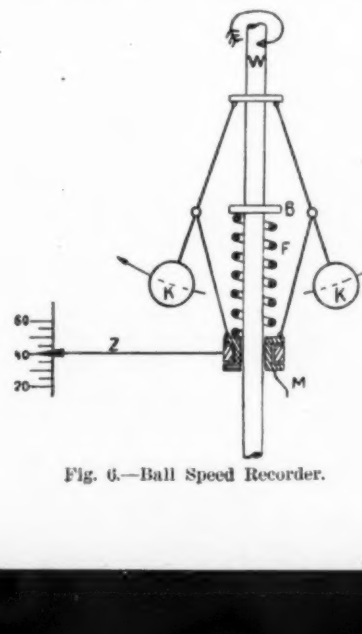


Fig. 6.—Ball Speed Recorder.

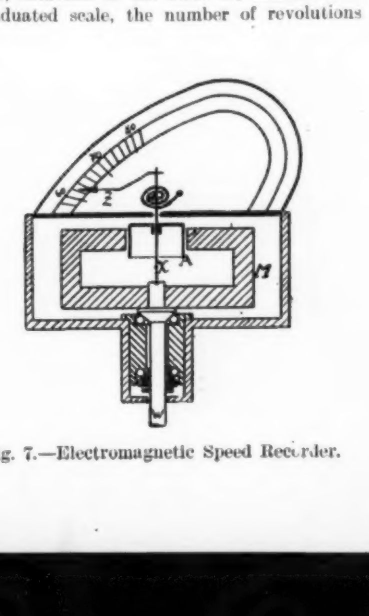


Fig. 7.—Electromagnetic Speed Recorder.

Young Hooded Seals in the Zoological Park. When Feeding Time Arrives the Young Seals Are Very Alert.

The Hooded Seal of the North Atlantic*

One of the Most Important Industries of Newfoundland

By Harry Whitney

EXCLUSIVE of the walrus, there are five distinct species of seals inhabiting the Atlantic waters contiguous to northeastern America: the Harbor or Ranger seal (*Callocephalus vitulinus*, Linnaeus), a small coastal breeding seal which frequently ascends fresh water streams; the Ringed seal (*Phoca hispida*, Schr.), also a small coastal breeding seal; the Harp seal (*Phoca gruenlandica*, Fabr.), somewhat larger than the two preceding seals, and, unlike them, breeding upon the north Atlantic ice floes; the Bearded or Square-Flipper sometimes called the Big seal (*Phoca barbata*, Fabricius), a very large seal, breeding along the northern coasts; and the Hooded or Bladder-Nose seal (*Cystophora cristata*, Erxleben), which, like the Harp seal, gives birth to its young upon the winter-formed ice floes of the north Atlantic.

The five young seal pups which I brought from the north in May, 1912, and which are now in the New York Zoological Park, belong to this last species, and a brief description of the species, its habits and its economic value, may be of interest to our readers.

In size, the Hooded seal ranks second to, and sometimes rivals, the Bearded seal, which is classed as the largest of the Atlantic seals. A full-grown Hood "dog" will not infrequently measure from eight to nine feet in length, and tip the scale at one thousand pounds, while an old female Hood will often weigh between eight hundred and nine hundred pounds.

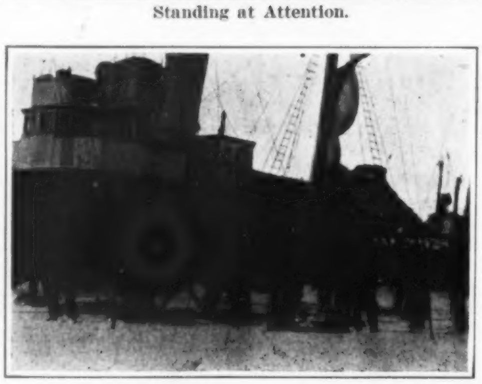
In color, the adult is bluish-black on the back, with a belly usually of lighter shade, varied with paler spots, though sometimes the belly is of a light-grayish tinge, with darker spots.

The male has a muscular sac or bag extending from the nose backward to the center of the head. This bag may be inflated at will, forming a hood-like covering to the head. It is this hood which gives the species its name.

The Hooded seal has one other distinctive feature. While each of the other four species mentioned has six front teeth or incisors in the upper jaw and four in the lower jaw, the Hooded seal has but four above and two below.

* Reproduced by permission of the Zoological Society from its *Bulletin*.

Standing at Attention.



Bringing the Seals to the "Neptune."

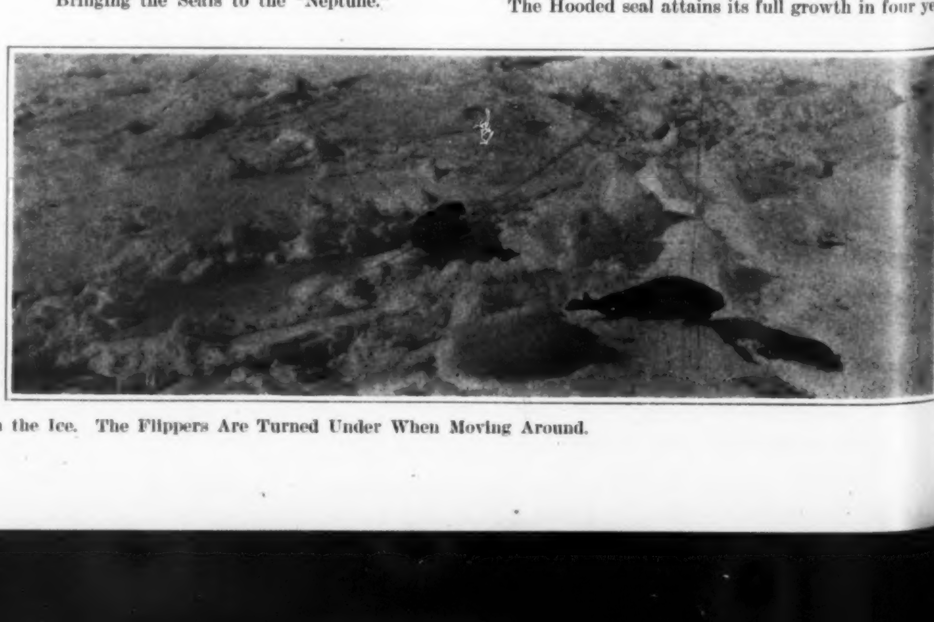
Both males and females will attack their enemies with boldness and savage ferocity, and in all my experience I have never encountered a more determined or dangerous antagonist among wild beasts than an angry Hooded seal brought to bay. I have seen an old dog Hood seize a gaff between his teeth and chew it into splinters. They travel upon the ice with remarkable speed, and the hunter must always be alert, prepared to meet their vicious charge.

Hood pups are nursed by their mothers until about two weeks old, when they are left to forage for themselves. After capturing the five little pups now in the Bronx Zoological Park, and taking them aboard our ship, the "Neptune," I was confronted with the difficulty of securing proper food for them, and it occurred to me to examine the stomachs of the carcasses of several of the old ones which had been killed. To my surprise I found that all I examined contained perfectly fresh herring, and in nearly every instance the fish were whole and entirely free from injury, without a tooth mark or scratch. From a single one of the old dogs I secured in this way six large fish. It is claimed that the seal herds off the Newfoundland and Labrador coasts destroy more codfish and herring each year than are taken by the entire fishing fleet.

The Hooded seal is migratory in its habits. During the summer the greater herds are found along the southeast coast of Greenland. In February and March they appear in countless numbers on the winter-formed ice floes off the Labrador and Newfoundland coasts, both in the open Atlantic and in the Gulf of St. Lawrence. It is at this time that they give birth to their young upon the floes, where they are found in families consisting of the mother seal, her pup and two or three old males. I have seen few instances where a seal gave birth to more than one pup in a season.

The pup is a shapeless, furry, steel-gray ball when first born, but grows and assumes shape with truly wonderful rapidity. It is safe to estimate that it increases three or four pounds in weight in each twenty-four hours during the first eight days after birth. The stormier the weather and the more snow that flies, the better it thrives.

The Hooded seal attains its full growth in four years,



Hooded Seals on the Ice. The Flippers Are Turned Under When Moving Around.

and competent observers state that they begin breeding at that age.

It sometimes happens that large herds become imprisoned upon the floes, through long continued winds in one direction which raft the ice and cut off their retreat. When this occurs and the seals are long exposed to the strong rays of the sun, their skins burn and crack, and they are subject to intense suffering. When in this condition, at times when the ice parted, permitting them to again return to the sea, I have observed them jump clear of the water, giving bellows of pain that could be heard for a long distance. When the skins are thus burned they are valueless, and the animals are not molested.

The value of the Hood, and, in fact, all species of North Atlantic hair seals, lies in its hide and blubber. The hide is tanned into leather, and the blubber converted into oil. From its hide, wallets, traveling bags and other fine leather goods articles are manufactured. The oil is utilized in many ways. It has even been said that no small proportion of high-grade seal oil which finds its way into the Italian market, passes through a process of deodorization and refinement and is launched upon the market by the resourceful Italian as "olive oil."

Sealing has long been one of the most important industries of the colony of Newfoundland. The seal fishery, it is said, had its beginning early in the eighteenth century, and the records of the Newfoundland Board of Trade state that as early as the year 1742, Fogo and Twillingate reaped a profit of nearly three thousand pounds sterling from trade in seal oil.

In the early days sealers went to the ice in sailing craft, but in 1862 the "Bloodhound" and the "Wolf," the vanguard of the present large fleet of sealing steamers especially fitted for the work, were introduced, and a new era in seal hunting began. It is the object of the sealers to find the floes upon which the herds are located, and this done, old and young alike are slaughtered upon the ice. Late in the season, after the young have taken to the water, a sealing steamer will sometimes follow a large herd at full speed for a hundred miles, or until the herd, becoming exhausted, takes to the ice floe again for rest. When thus thoroughly wearied they will not at once return to the water, and are spoken of as "beat out." After a long drive of this kind they are very poor, and large lumps form under each flipper.

The Harp, the one other species, as previously stated, which whelps upon the ice, though a much smaller seal than the Hood, is more valuable, and is found in much larger herds than the Hood. The young of this species is snow white until two weeks old, when it sheds its first coat and assumes a dark slate color.

The seal hunt was at its zenith in 1831, when 686,836 seals were captured. In 1911 the total numbered 304,591. Capt. Abraham Kean, with the "Florizel," captured the largest number of any one ship during that year, his catch reaching a total of 49,129, of which more than half were Harps.

Tracking Wild Animals by their Spoor

An Attractive Field of Observation

Among the various forms of wood-craft which appeal alike to the sportsman, the country-dweller, the naturalist, and the mere lover of nature, none is more fascinating than the tracking of wild animals by their spoor.

This art is susceptible of a very high development by the combination of close observation and critical deduction. Not only the presence of the animal and the approximate time of its passage may be determined, but its species, its age, its size, and its sex.

M. Martin discusses entertainingly in *La Nature* the methods of such study.

"From the most primitive times," he observes, "man, surrounded by all sorts of animals, has been obliged to gather from their tracks useful information, either for the purpose of catching them or of escaping them; and even to-day, certain savage tribes, by studying the traces left by game have acquired an almost incredible skill in tracking them over the most varied ground in widely differing circumstances. Not gifted like the carnivora with the ability to track his prey by the scent, man has been forced to depend on reason and acquired experience.

"No confusion is possible between the prints of hoofs and those made by the feet of the carnivorous mammals. In the case of the latter, let us take for example four species having a different manner of walk: the badger and otter, which are plantigrade, show an impress made by the five toes of each foot; the cat and the fox, which are digitigrade, show only four toes.

"If the plantigrade imprint shows the track of short nails, slightly indented, it belongs to the otter, while that of the badger shows nails long and clearly marked, extending in front of a sort of hand.

"As for the cat and fox, the first, whose nails are retractile, shows no trace of them, while the latter shows a straight nail extended in front of each pad of the foot. Hence, the tracks are easy to distinguish.

"The foot of the fox, indeed, is more similar to that of many other mammals, e. g., it much resembles that of a small dog, such as a terrier; but in this case, if the track is sufficiently marked the thick coat of fur between the pads immediately reveals Reynard. It has also some analogy to that of the martin and the beech-martin, but these two species are smaller and their tracks are notably longer and narrower.

"Among the rodents, the impression left, when very clear, shows four digits. That of the hare, especially, is somewhat oval and very furry. Its shape is clearly indented on soft ground, but when the earth is dry only the point of the foot may be marked with the trace of nails generally clearly shown in front.

"As we see, each species has its own peculiar imprint, but this, larger or smaller, according to the size and age of the individual, may also vary slightly in animals of abnormal form.

"It is important also to judge the time at which the imprint has been made. If, for example, the foot has been placed in a puddle of water, and the water is still troubled the passage of the animal has obviously been very recent; if water still seeps into an impression made in humid soil, the passage must have taken place within a few hours; if the mud is dried about the edge of the track a considerable time must have elapsed. Moreover, account must be taken in each instance of conditions of wind and temperature and character and action of the soil.

"The same remarks apply to hoofed animals, such as the stag, goat, and wild boar. The foot of the last much resembles that of the domestic pig, but in the wild animal the mark of the heel is generally less deeply marked, while the front of the foot and ends of the toes are very distinct. The pig, on the contrary, bears rather more on the heel. At the rear of the hoof, moreover, the print of the boar's foot has two indentations or grooves, cut by the spurs. The age of the animal may be judged by the depth of these. Sometimes, too, one of the toes is longer and more recurved than the others.

"The study of the spoor of the stag is especially interesting, because the animal varies greatly as it increases in age, and it is a great advantage to the hunter to judge merely by the track both of age and sex. In the female the foot is comparatively long and narrow, the toes of the four feet spread apart, while the male has larger hoofs, with those of the hind feet stronger than those of the fore feet; the gait, especially if it is old, is more regular, and while traveling the toes of the hind feet are usually closed. In measure as it grows older the feet grow in size, the horny part of the hoofs is worn away, and the ends of the toes become more and more rounded, while at the same time its weight increases; these are all progressive changes which serve to indicate age and which are shown in the tracks. It must, of course, be remembered that the feet wear off and become rounded more quickly if the earth of the forest is hard and rocky, and less rapidly if the animal lives on a soft clay soil; also in some regions the deer are larger and more vigorous than in others.

The Spoor of Various Wild Animals. 1. Badger's Front Paw; 2 and 3, Front and Hind Paw of the Otter; 4 and 5, Front and Hind Paw of the Wild Cat; 6, Front and Hind Paw of the Fox; 7, Front and Hind Paw of a Ferret; 8, Front and Hind Paw of a Hare; 9, the Hind Foot of a Boar.

"In following on foot the spoor of a mammal other significant signs accompanying the tracks are often seen, such as *dijecta*, an overturned stone, a patch of scraped earth, crushed herbage, browsed foliage, etc., which permit an easier decision as to the animal's size, weight, and gait.

"The study of the tracks left by animals on forest ground is a most attractive pursuit, which develops the powers of observation and which interests both the landed proprietor and the passing pedestrian as fossil imprints interest a geologist. A very great pleasure may be found in resolving a series of problems: the affirmation of the species, judgment as to size, age, and sex, and action at the moment the track was made. The proper experience once acquired, the observer will solve these problems quite as well and sometimes even better than if he saw with his own eyes the creature flee past him in the midst of the forest.

"Experience and logical reasoning are, in fact, more accurate in many circumstances than vision. Nothing can better justify this assertion than the example of d'Yanville, a celebrated huntsman of the eighteenth century. The stag he was following lost its antlers in the course of the chase, and thus disburdened bounded past many hunters and passers-by. These people thought to have seen with their own eyes a *doe* and not a stag; they affirmed this in d'Yanville's presence. But he examined the trail and ordered the chase to go on. 'My eyes,' he said, 'told me, to be sure, that the animal was a doe, but my reason tells me the foot is that of a stag.'"

A New Case of Mutation

At a recent meeting of the German Horticultural Society, Mr. Walter, of Vevey, presented a series of cyclamens having a remarkable character. Six years ago he suddenly obtained a white cyclamen plower in which the plowers instead of being turned downward as usual were now turned up like most plowers. In most species of cyclamen the stem is strongly curved at the base of the plower so that this has its face downward, while the curved lobes of the coralla are upturned. In the new specimen the stem was straight and the plower was accordingly turned upward, with the coralla lobes downward. Mr. Walter then made numerous crossings with this plant, and found that the upturning which had been suddenly obtained by mutation, was seen in all the hybrids since the first generation. Thus the effect appears due to a dominant quality. He obtained cyclamens of various races and colors, all of which were upturned, and the results are very interesting for the mutation theory.

The Light Quantity Hypothesis*

New Ideas as to the Atomic Nature of Radiant Energy Which Promises Solutions of Many Difficulties

By Prof. D. F. Comstock, of the Massachusetts Institute of Technology

WITHIN the last few years the idea has been gaining importance that the light radiated from a luminous body is not emitted continuously, but in small indivisible "atoms of energy." This notion is totally unexpected from the standpoint of a decade ago, but evidence of one form or another is piling up so fast that it appears at present highly probable this view will, in the end, prove to represent the truth.

The idea was first put forward by a physicist of international fame, Prof. Max Planck, of the University of Berlin. He was led to this conclusion through his study of the so-called laws of radiation.

RADIATION FROM A BLACK BODY.

In order to make a discussion of this hypothesis at all clear, it is necessary to speak of the phenomena of radiation in general. The simplest type of radiation which we know is that which a so-called "black body" gives off when heated. Perhaps the simplest black body we could take would be a tin cup covered with lamp black on the outside and filled with hot water. This body gives off heat rays in all directions which, as far as we know, differ in no way whatever from light rays except that they are on the average of a lower frequency, i. e., they bear the same qualitative relation to light rays that the lowest note in the piano scale bears to the highest. These rays do not affect the eye because the retina is not so constructed that it can detect such relatively slow vibrations. The laws of propagation of the waves and their general characteristics are apparently, however, exactly the same as those of light rays.

Now, if we suppose the cup filled with something besides water and to be slowly heated hotter and hotter, we should notice two significant changes in this radiation which spreads out in all directions from the cup. In the first place, as it gets hotter, *more energy* will be radiated in a unit of time, and second, such energy as is radiated will have a higher average frequency than before. Making a sound analogy, we might say that this corresponds to the sounds given off being *louder* and of *higher pitch.* If this heating process goes on indefinitely the frequency will soon be high enough so that the retina of the eye will be affected by the rays and the object will be "red hot."

WHERE WIEN'S FORMULA FAILS.

Now the exact way in which the radiation of a black body changes with increasing temperature, has been studied very carefully and several theoretical formulæ have been found which agree more or less closely with experimental results. Perhaps the most successful of these is the so-called formula of Wien which was derived from the fundamental conceptions of atomic theory. It is almost certainly true that the radiation from a hot body is caused by the chaotic to-and-fro motion of the atoms or molecules of which the substance is composed, and the general distribution of motion among the vibrating molecules or atoms is pretty well known at the present time. Wien obtained his formula by supposing that each molecule radiated energy in a way which depended only on its velocity at the instant in question.

Now, although Wien's formula certainly contains some element of truth, it fails conspicuously at high temperatures. This failure has been realized for a number of years, but no suggestion was forthcoming as to *why* it failed.

This failure of Wien's formula is by no means an isolated fact of small importance. The ablest thinkers in theoretical physics all over the world have considered at great length the theory of radiation, and although there has been more or less complete agreement among them, their results are not accurately in agreement with the results of experiment. Indeed a decade ago it was generally admitted that something was wrong with the fundamental notions the theory.

PLANCK'S "ATOMS OF ENERGY."

In about 1905, however, Prof. Planck came forward with an entirely new hypothesis. By one of the mysterious mutations which we call "inspirations of genius," he came to the conclusion that if we were to get a theory consistent with experiment, we must assume that the atoms do not radiate energy continuously, *but radiate only in small discrete quantities—"atoms of energy" one might say.* From this point of view the oscillating part of an atom cannot possess *any* amount of energy, but only an amount which is a definite multiple of a fundamental unit of energy.

This is an extraordinary assumption and is in a sense a sudden jump in physical theory, but Planck showed that when one developed this hypothesis by well-known and rigid methods, an equation was obtained which differed slightly from Wien's formula and which was much more hopeful in its form. As a matter of fact, careful experiments have shown that as accurately as measurements have been carried out, Planck's formula is exact for all temperatures.

It is an interesting and suggestive fact that Wien's formula appears as a special case of Planck's when the temperature is not too high. In other words, Planck's formula contains apparently all the truth that is in Wien's and enough more to make it an exact representation of the fact. It is also an interesting side-light on the rapidity with which apparently remote scientific hypotheses may react on the industrial world, that Planck's formula is already beginning to have an important effect on interpreting the results of the so-called optical pyrometers so extensively used in measuring the high temperatures of furnaces.

So extraordinary is the assumption of discrete quantities of energy that, were it only applicable to the theory of radiation, the conception would not be as impressive as it has grown to be within the last few years, but curiously enough there is totally independent experimental evidence for it. Other results seem to indicate that light and similar wave motions propagate in the form of units of energy.

THE SHOWER-OF-STONES ANALOGY.

It is a well-known fact in physics that if a current is passed through any vacuum tube in which the vacuum is very high, a stream of electrons proceeds from the negative terminal in the tube and travels in straight lines. This stream of electrons constitutes what we know as the cathode rays. When these rays strike any obstacle, X-rays are emitted from the point struck, just as sound would be emitted from a barn door struck by a shower of stones. These X-rays are considered to be of the wave-motion type of disturbance and not a stream of particles. The shower-of-stones—sound analogy—is, therefore, quite accurate since sound is a wave motion. The analogy, however, fails of further application for it is found that when these X-rays strike a metal they give rise to a stream of cathode rays (i. e., a stream of electrons) which are called the "secondary cathode rays," and these cathode rays give rise to other X-rays. If the stone analogy were to be complete, the sound from the point struck by the stone would have to cause a stream of stones to come out of any substance which the sound struck.

Now, the curious fact noticed about these electrons which spring out of a metal when it is struck by X-rays is that their maximum speed does not seem to depend on how intense the X-rays are, nor does it depend on the nature of the metal struck by them. If a piece of metal is taken farther away from the source of rays, so that the energy of the rays falling on it is less, it is found that fewer electrons come out of the metal in a unit time, but those that do come out have the same maximum velocity that they had when the metal was nearer.

Now, a little thought will show that this result is totally inexplainable on the older ideas of radiant energy, for the energy of the outcoming electrons is evidently derived from the energy of the striking X-rays, and as this energy spreads out indefinitely and gets weaker, it is to be expected that all effects produced by the energy would slowly dwindle away. This is not true, however; the emitted electrons come out with the same maximum speed as when far more energy struck them.

Now, on the "light quantity hypothesis," the results are quite clear, for if the energy of the X-rays is really in the form of little "particles" of energy, then at greater distances from the source of the rays, the only difference is that the particles would be farther apart on the average. They are spread out more, but each has the same amount of energy and each is, therefore, capable of giving an impulse of the same strength to the electron in the metal which it happens to strike as it would have given had the metal been nearer; so that the experimental results, totally inexplainable on the older idea of continuous energy radiation, become readily explained when this "light quantity hypothesis" is applied.

"ABSOLUTE ZERO" AND THE NEW HYPOTHESIS.

Besides these two rather striking examples of the evidence for the light quantity hypothesis there are a number of others in which it is either definitely suggested by experiments or dimly foreshadowed. One set of results which seems to promise evidence in favor of the hypothesis is obtained in modern low temperature research. As is well known, the theoretical limit in diminishing temperature is the so-called "absolute zero." This is the temperature at which all atomic energy, or molecular energy of vibration would cease and is located at approximately 273 deg. Cent. below zero or 460 deg. Fahr. below zero. It is only very recently that temperatures at all approximating the absolute zero have been obtained but now we have results on the electrical resistance of platinum wire measured at 1.5 deg. Cent. above the absolute zero. At this temperature air and even hydrogen are solid.

Now, at these very low temperatures there are certain unexpected anomalies in both electrical and heat phenomena.

The so-called specific heat of substances, which from the older ideas should approach a certain definite constant as the temperature approaches the absolute zero, changes in quite an unexpected way as the temperature diminishes, for at these very low values it becomes so rapidly less as to approach zero instead of the constant finite value as above mentioned. It is very difficult to get any explanation of these low temperature anomalies on the older ideas of continuous energy distribution. On the energy quantity hypothesis, however, the results while not yet worked out sufficiently to be called at all certain, are, nevertheless, very suggestive and promising.

FLUORESCENCE AND THE SIZE OF THE ATOMS OF ENERGY.

Even in the domain of fluorescence an obscure question seems to be on the point of being cleared up by light quantity ideas, for it is well known in general, that fluorescent light is nearly always of lower frequency than the light which causes the fluorescence. This is in line with the new ideas, for although not yet mentioned in this paper, *the so-called atoms of energy are not all of the same size, but are larger in proportion to the frequency of light,* so that the size of the "atoms" corresponding to blue light, is greater than the size corresponding to red light, and it is clear, therefore, that when a body fluoresces, under stimulation from light of any color, it cannot give off larger light atoms (i. e., bluer light) than it receives from the stimulating light, whereas it is perfectly conceivable that through some type of complex transformation, some of the energy might be left in a body and the energy quantities in the fluorescent light might be smaller, that is, the fluorescent light might be redder.

The light quantity hypothesis has not by any means been worked out so completely yet that its position and possibilities are well defined, but it seems at present full of promise, and it is being used more and more by physicists throughout the world in explaining phenomena hitherto mysterious both in the realm of radiation and in that of electricity.

* Reproduced from *Science Conspectus.*

Soap for Cleaning Very Dirty Hands.—It is well known that chauffeurs, mechanicians and others whose occupations are essentially dirty and involve soiling with axle-grease, cleanse their hands by washing them in petroleum essence or rubbing them with oil, before resorting to soap and water. This is not always practical or feasible. For this reason there have been brought out, with profuse advertisement, various special soaps, some of which are effacious, while others are not. It is easy to prepare such products by incorporating with the soap some kind of abrasive substance which scrapes the skin and absorbs the dirty grease. Do not use sand, which imparts, on use, a very disagreeable feeling, but finely sifted sawdust or cork powder, and use a sufficient quantity, 10 per cent, for instance, taking care to rinse it thoroughly and to avoid leaving the mass to stand as long as it is liquid. Practically and on a small scale, it is best to use a fat soap. Its efficacy can be increased by adding uniformly, before using, a little grease solvent, petrol essence, benzine, denatured alcohol, but not too much, because then the mass, too fluid, deliquesces when standing. There should be undertaken, for an industrial manufacture, a study of a combination of soap, sawdust and solvent, having exactly or nearly the same density as will produce a very permanent emulsion. Without doubt, one can easily obtain this by mixing various chlorine derivatives of hydrocarbon, so as to obtain a solvent that will be non-combustible and but slightly volatile.—*Les Matieres Grasses.*

Trisecting a Given Angle

A Mechanical Solution

By Felix Alexander Joseph

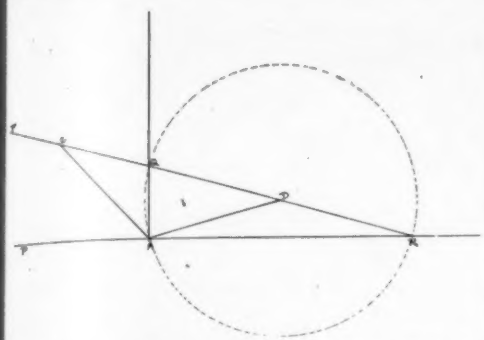


Fig. 1.—Diagram Showing the Principle of the Method.

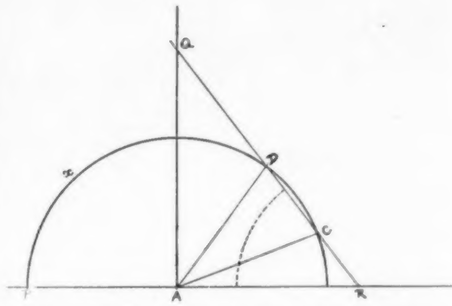


Fig. 2.—Solution for an Angle Between 90 and 180 Degrees.

The following method of mechanically trisecting any given angle between 0 and 360 degrees occurred to me some years ago.

The principle on which it is based is shown in Diagram 1.

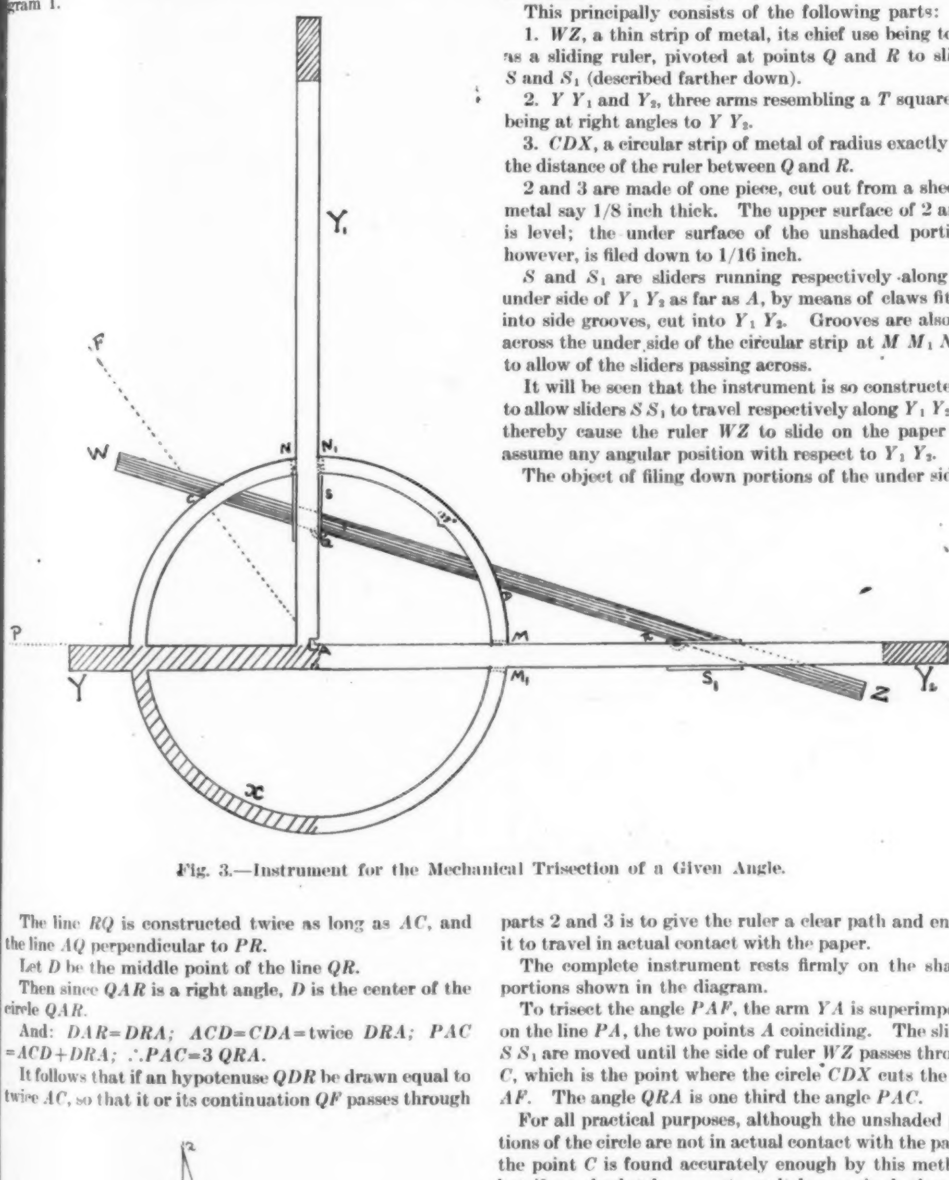


Fig. 3.—Instrument for the Mechanical Trisection of a Given Angle.

The line RQ is constructed twice as long as AC, and the line AQ perpendicular to PR.

Let D be the middle point of the line QR.

Then since QAR is a right angle, D is the center of the circle QAR.

And: $DAR=DRA$; $ACD=CDA=$twice DRA; $PAC=ACD+DRA$; $\therefore PAC=3\,QRA$.

It follows that if an hypotenuse QDR be drawn equal to twice AC, so that it or its continuation QF passes through any point C, the angle QRA will be one third the angle PAC. If such an hypotenuse could be drawn strictly according to Euclidean methods, the trisection problem would be immediately solved.

To accomplish this mechanically, I have designed the instrument shown in Fig. 3.

This principally consists of the following parts:

1. WZ, a thin strip of metal, its chief use being to act as a sliding ruler, pivoted at points Q and R to sliders S and S_1 (described farther down).

2. $Y\,Y_1$ and Y_2, three arms resembling a T square, Y_1 being at right angles to $Y\,Y_2$.

3. CDX, a circular strip of metal of radius exactly half the distance of the ruler between Q and R.

2 and 3 are made of one piece, cut out from a sheet of metal say 1/8 inch thick. The upper surface of 2 and 3 is level; the under surface of the unshaded portions, however, is filed down to 1/16 inch.

S and S_1 are sliders running respectively along the under side of $Y_1\,Y_2$ as far as A, by means of claws fitting into side grooves, cut into $Y_1\,Y_2$. Grooves are also cut across the under side of the circular strip at $M\;M_1\;N\;N_1$ to allow of the sliders passing across.

It will be seen that the instrument is so constructed as to allow sliders $S\,S_1$ to travel respectively along $Y_1\,Y_2$ and thereby cause the ruler WZ to slide on the paper and assume any angular position with respect to $Y_1\,Y_2$.

The object of filing down portions of the under side of parts 2 and 3 is to give the ruler a clear path and enable it to travel in actual contact with the paper.

The complete instrument rests firmly on the shaded portions shown in the diagram.

To trisect the angle PAF, the arm YA is superimposed on the line PA, the two points A coinciding. The sliders $S\,S_1$ are moved until the side of ruler WZ passes through C, which is the point where the circle CDX cuts the line AF. The angle QRA is one third the angle PAC.

For all practical purposes, although the unshaded portions of the circle are not in actual contact with the paper, the point C is found accurately enough by this method; but if an absolutely correct result be required, then the lower left hand quadrant of the circular strip (which is in contact with the paper) should be used for determining the length of AC.

It will be noticed that though the angle QRA is one third the angle PAC, the actual trisection of PAF is, strictly speaking, not accomplished until a parallel line to QR is drawn through the point A. This is easily effected by means of a light parallel ruler pivoted at A (one arm of the parallel attachment being pivoted at A and D), but for simplicity's sake this has been omitted from the diagram.

In the above case the angle PAC was taken as being less than 90 degrees. That the relations on which the method is based hold good also for angles between 90 and 360 degrees is easily shown.

In Fig. 2 PAC is taken between 90 and 180 degrees. In this case the hypotenuse QR and not its continuation passes through the point C.

$DAR=DRA$; $QDA=ACR=2\,DRA$; $\therefore PAC=3\,QRA$.

It should be noted that with angles between 90 and 180 degrees, through every point C, two lines of length QR can be drawn. One line will always have C coinciding with the middle point D of the ruler (Fig. 2). The other and correct line has C to the *left* of D, if the angle is under 135 degrees, and to the *right* of D, if over 135 degrees. It may be worth remarking that the halfway point D of the ruler QR always lies exactly on the arc CDX, irrespective of the direction of the ruler.

A pencil fixed at D would, therefore, afford an easy means of drawing the circle CDX without using its center.

In Fig. 4, PAC is taken between 180 and 270 degrees.

$DAR=DRA$; $QDA=2\,DRA$;

$ADC=ACD$; $DRA=RAC+ADR$.

Now $QDA+DRA=DAR+DRA+ADR+RAC$
$=2$ right angles $+\,RAC$.
$=PAC$.

$\therefore QRA$ is one third the angle PAC.

In Fig. 5, PAC is any angle between 270 and 360 degrees. In this case the arm Y_1 of the instrument is superimposed on the line PA.

$DRA=DAR$; $ADQ=2\,DRA$;

$\therefore$ angle $TVW=2\,QRP$.

Now $TVW+QRP=2$ right angles $+\,2\,RDA+DAR$
$=2$ right angles $+\,HAD+DAP$
$=PAC$

$\therefore QRP=$one third PAC.

An instrument based on the above principle is clearly shown to be capable of being constructed to give absolutely true results. And in comparing the mechanical process effected by such an instrument with say the usual method of joining any two given points by a straight line drawn with an ordinary ruler, although the latter falls within the recognized limits of Euclidean construction, the former would appear to be more truly accurate. For the latter process is evidently one of approximation only, as it is taken for granted that it is possible to place the side of the ruler exactly in the position of, or parallel to, the line joining the *two* given points. With an instrument as described above, accurately constructed, there is, however, no such question of approximation, as there is only *one* point (the point C) through which the side of the ruler WZ is required to pass.

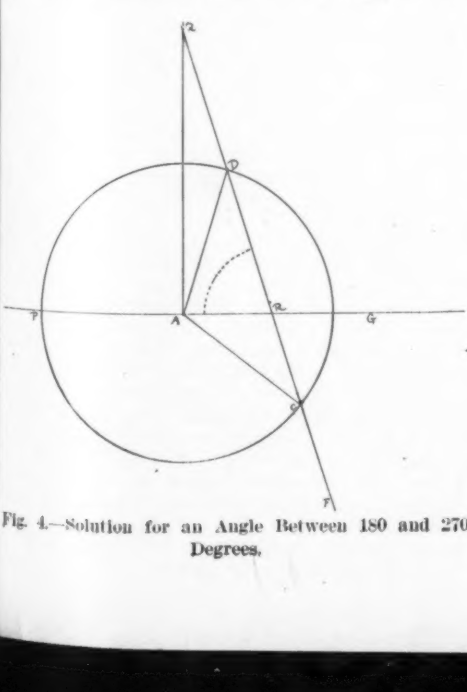


Fig. 4.—Solution for an Angle Between 180 and 270 Degrees.

Printing on Celluloid.—An ink for use to print from rubber type on celluloid is made up of 1 part shellac, 1 part spirit of camphor, and 3 to 4 parts of alcohol (90 per cent), colored to suit with aniline dyes.

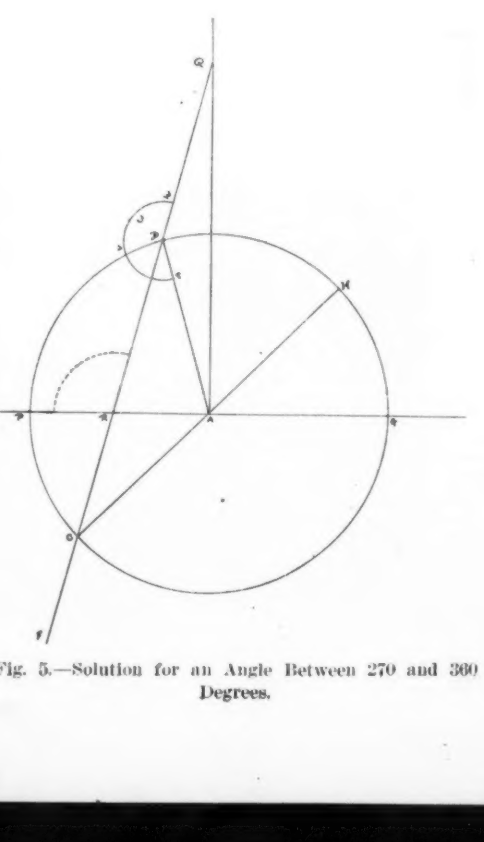
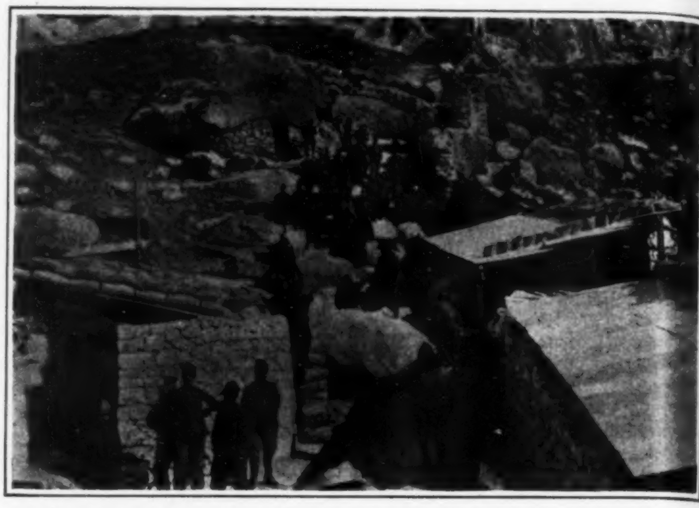


Fig. 5.—Solution for an Angle Between 270 and 360 Degrees.

Regiment of Italian Artillery Defiling Through Menscia Garden, Planted in Sandy Soil, Tripoli; Similarly Beautiful Garden Areas Have Been Laid Waste by the Operations of the Italo-Turkish War in This Vicinity.



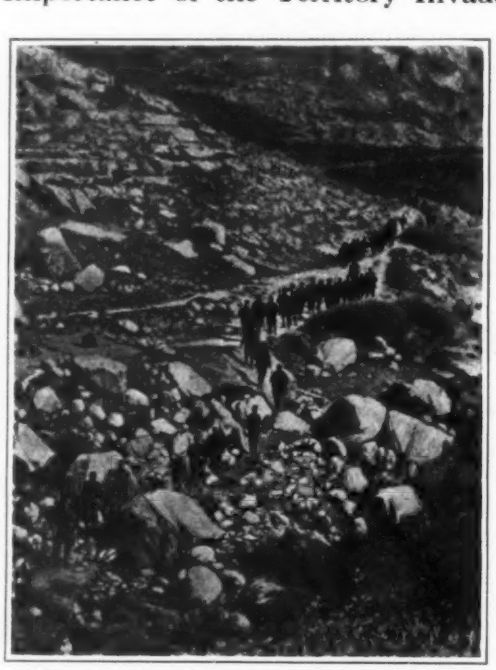
The Desolate Rocky Highlands of Derna Provide the Italian Forces With Almost Natural Redoubts From Which to Repulse Attempts by the Enemy to Retake That Important Coast Stronghold of Cyrenaica.

The Resources of Tripolitania and Cyrenaica

Economic Importance of the Territory Invaded by Italy

Italy's programme for the utilization, for her immense surplus population, of the vast North African territory of Tripolitania and Cyrenaica, which her armies have invaded, embraces the reclamation of even those bleakest and most desolate regions long regarded by the world at large as desert land. Indeed, one of the foremost of Italian economists, Prof. P. Vinassa de Regny, of the Royal University of Parma, ardently disputes the applicability of the term "desert" to the major portion of the country. By a scientist's arraying of statistics, the result of exhaustive recent investigation, and of arguments which impress by their logical honesty, he has lent encouragement to the faltering hopes of his nation that the newest of its colonies might be transformed into one of the fairest of the earth's garden spots. There is water in plenty in the Cyrenaica and in Tripolitania, he declares, and he urges his countrymen to retrace the not wholly obliterated irrigation canals by which the Romans brought the coast plains of both territories to a high state of cultivation. If an ancient civilization could produce in abundance barley, olives, wine, why should not its latter-day descendents do likewise? The agricultural problem confronting the Italians on the other side of the Mediterranean, he asserts, is not more formidable than that which the system of dry farming—a heritage from the Romans—has successfully solved for arid stretches of the western United States.

A chief aim of future study and one indispensable to a proper economic appraisement of the new territory, Prof. de Regny avers, should be the research of the ancient hydraulic provision system. Stagnant lakes of impermeable clayey beds invariably may be traced to true springs, which, although abandoned and almost obliterated by time, are not really lost. It is always possible to trace them, as it is, also, the conduits of the Romans, which proceed from neighboring springs.



Defiling of Italian Infantry Through Rocky Ravine Near Derna, in Cyrenaica, on Advance to Protect Water Source Prior to Establishment of a Blockade; Sparse Grasses Derive Sustenance From Underground Streams of Water.

"The waters of the sky are dead, but those of the sun (the subterranean waters) live," is an Arabic proverb which the scholar of Parma quotes in support of his plea for the settlement of the waste lands by Italians, while, too, he confounds popular notions regarding the Tripolitan desert.

Writing in the *Rivista d' Italia*, Prof. de Regny observes:

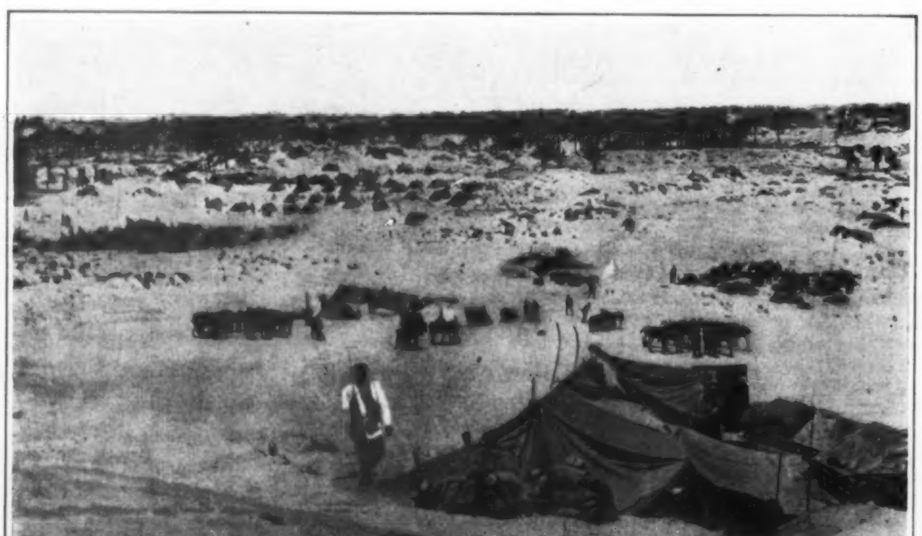
"The great mass of the people and many of the better informed classes regard the desert as a vast uniform waste of sand. The idea is erroneously maintained that the desert is an erstwhile basin of the sea, in which the sands have been left to dry; the facts, instead, are quite the contrary.

"The desert is of three very distinct types. The Hammada is the rocky desert—naked stone, polished by the wind, with not a grain of sand, not a drop of water is sight, nor shade, nor any trace of life. Such, for example, is the Hammada el Homra (Central and Southern Tripoli) which for more than one hundred and twenty miles extends, flat and desolate, between the two nearest wells. It is a veritable graveyard for caravans; we must look for the day when a railway, occasioning no extraordinary problems of engineering, shall traverse this region in four hours, instead of the two weeks, more or less, now consumed by caravans.

"After the Hammada comes the second type of desert, the Serir, that is a gravelly desert. To the south of the high plain of Cyrenaica and reaching to Cutra (oasis) one may journey for a week over a space covered with pebbles no larger than a nut.

"We come finally to the third type of desert, the one most familiar to the popular mind, but not the most common, in fact—the Edeien, or sandy desert, of which the Erg, on the Tunisian frontier of Tripoli, is an example. It adjoins Ghedames on the west and it adjoins the Hammada on the east and on the north. In the Edeien are the impalpable sands into which the wayfarer sinks, while the drift fills his eyes, his mouth, ears and nostrils. It finds its way into the food and the water—wherever quartzose sands may penetrate—and borne by the wind, it injures the eyes and draws the blood from the exposed skin. But in the very midst of the sands of the Edeien are the verdant spots called oases.

"We shall commence with the Oasis of Cutra, the seat of the Senussi tribesmen. This is a grouping of oases which is said to have the extraordinary area of close upon 20,000 square kilometers. The soil is marshy, and at a depth of from one to three meters water is found. As it never rains at the Oasis of Cutra, the waters must have a distant source; in fact, they must proceed from the great interior mountain strongholds of Tibesti and the Uagiaga, and being conveyed over an impervious clayey stratum, they flow to the depression of the oasis. For us this fact is of the utmost importance. The presence of abundant water in the hollow of the Cutra oasis reveals a subterranean stream along the stratum that proceeds from the mountains as far distant as Ciad. This is confirmed by soundings to varying depth, which give good results to the south of Cutra, and all along the caravan route. If we consider



General View of Italian Army Encampment at Bu-Sceifa, Near Cape Misrata, on the Tripolitan Coast; Life of Palm Trees in Distant Depressions Sustained by Annual Rainfall of From 450 to 500 Millimeters, Which Settles in Hollows.

ider that for 380 kilometers, the distance from Cutra o Aujila, not a drop of water is encountered, but that ne journeys over a tremendous waste of gravel, the ealization quickly dawns of the utility to which this egion may be brought by perforation of the soil to ap the waters flowing to Cutra

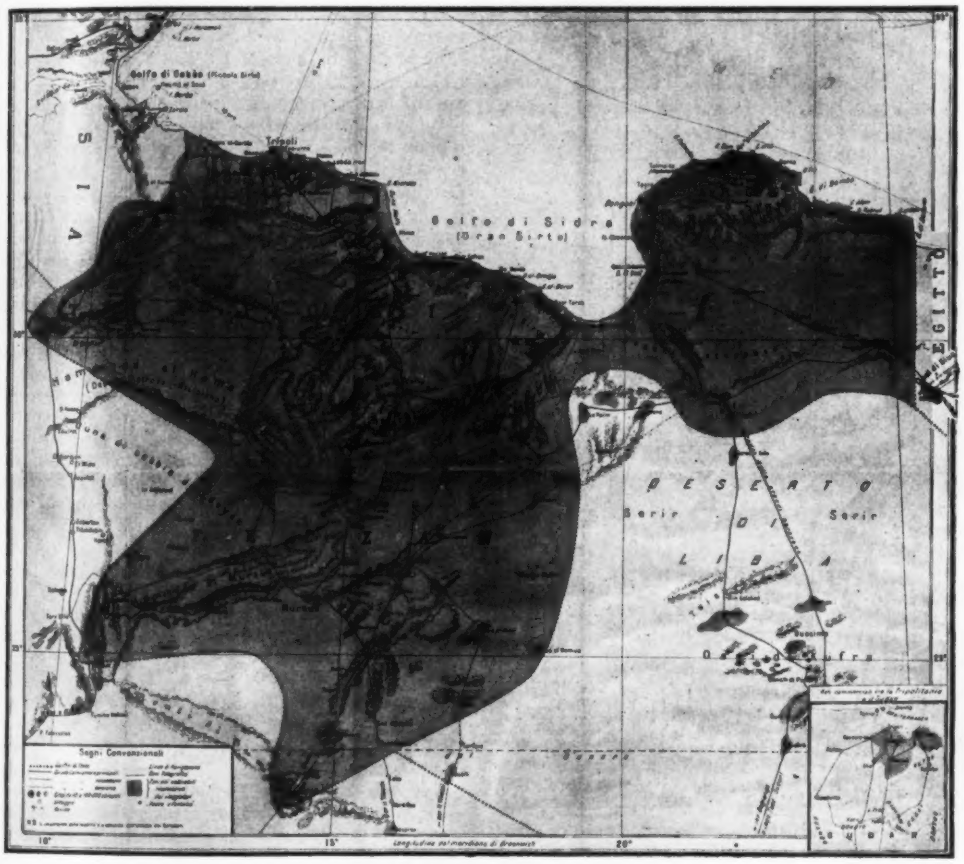
"The same conditions may be cited for Fezzan, which e would now call by its ancient Roman name of Fasania. The soil is of the best, but it is not arable, except in the lepressions; yet here water is found at slight depth nd of a purity sufficient for drinking purposes. In hese depressions it is, then, possible to grow the palm, nd, by irrigation, even with salt water, cereals, herbs, ruits, etc. Cotton and tobacco vegetate splendidly nder these conditions, and the best gum Arabic is roduced from the acacia. The almond trees also yield n exquisite fruit. This description might equally pply to the oases of Murzuk, of Gatrun, etc., from hich the best Fasania dates are produced.

"Leaving out of consideration the greater oases of he Cutra group, there yet remains an area of 20,000 quare kilometers covered by the other oases of Fasania. n some of these, as at Murzuk, the climate and the oul waters are deadly to Europeans; in others, while onditions are not so grave, cultivation by our people

populated regions. The appalling waste of these waters and the need for their systematic control and conservation are thus described:

"On the Tripolitan coast the waters fall on the plain and over Gebel chiefly in the winter months; of the eighteen to twenty inches of water that represent the annual average of precipitation, more than two-thirds fall in the months from December to February. When the rains are very violent, serious floods occur, such as that which wrought heavy damage to the city of Tripoli several years ago and such as that which recently destroyed our trenches facing the desert depression of Uadi Megenin. Waters of this sort must collect in great volume unless arrested. The work of defense at Tripoli cannot guard against this, and the real work must be done at Gebel. A useful outlet should be obtained for those waters, to obviate further danger of this character, and an effective check should be placed upon masses of this water whereby they might be stored in dammed reservoirs. In like manner, too, a good part of this water should be allowed to infiltrate the sub-soil, slowly, so that it may not be lost. The ground of Jetara, the sea-coast plain of Gebel, is ideal for the absorption of water.

"In the interior we find that the presence of the



Map of Tripoli and Cyrenaica.

would not be counseled. But by this I do not mean to infer that these oases should be disregarded. Their soil is excellent and fertile and water is obtainable at little depth, rendering them highly adapted to most intense cultivation, and the rational digging of new wells should greatly extend the area of actual vegetation. Arabs, Berbers, Bedouins would perform the real cultivation; we need no more than to encourage and assist the population, having freed them from the fiscal greed that under the wretched Turkish regime stifled all initiative.

The Italian empire, then, must limit itself to the technical direction of this activity, to the help of the people and to the regulation of commerce. At the present time the production of the oases sustains chiefly, or rather, exclusively, an immense date traffic; a caravan exchange between the coast countries, barren of dates, but rich in cereals, and the interior countries, rich in dates, but yielding no cereals. Millions of lire change hands among the population in the furtherance of this traffic, with an attendant employment of camels and of people truly grand in its proportions.

In confirmation, as it were, of Prof. de Regny's belief in a desert sub-soil, watered and of great productive capability, the Arabs cherish an ancient saying that the palm, most beautiful and most useful of trees of the desert regions, has "its leaves in fire and its roots in water."

The coastal region of Tripolitania is even encouraged to produce vegetation by winter rains, which are frequently so heavy as to cause serious damage to the

water is directly related to the morphology and the nature of the sub-soil. The waters that rain upon the highlands are conveyed to the depressions and there settle, giving origin to the oases and frequently, also, to malaria. A characteristic example is Muzruk, the center of the desert region, which, by the irony of fate, suffers from a great quantity of the stagnant and unhealthy water that surrounds it. Aujila, Socna, Gialo, etc., are all depressed oases, inclosed by the mountains or hills, the meteoric waters of which are shed in their direction.

"Along the coast from Gebel to the sea is a sandy plain, the Jetara—that which the correspondent and the venturesome holiday traveler, waiting between steamers at Tripoli, has surveyed from a coast ridge and called—'the desert,' sandy desert, to all appearances it certainly is, because it has been *reduced* to such by Mussulman inertia and that the Turkish Government—be it 'young' or 'old,' it makes no difference. But this apparent 'desert' may be restored upon a grandly extended scale, to a magnificent and flowering garden, when it shall be fructified by Italian labor.

"'Desolate African sands' is a time-honored phrase which did valiant service in connection with our occupation of Eritrea, where there is no sand and it has been repeated in satiety by the opponents of the present Tripolitan expedition. A great part of the Tripolitan coast, as we have seen, is truly all sand. Our opponents are right; in the name, not in the adjective. Sand, in fact, is all the soil of the oases and of the 'desert' that surrounds the oases—sand and a little clay. But

sand is full of fertilizing elements, possesses many advantageous properties, and in its mineralogical make-up is complete in all those chemical elements which are indispensable to the development of plant life. It would be difficult to imagine an African soil more fertile than this sand."

Regarding his investigations, made to determine the comparative productive capacity of the soil of the gardens of Tripolitania, already under cultivation, and of the sandy desert land not far distant therefrom, Prof. de Regny writes as follows:

"The most important soil that has presented itself to me for analysis is that of the gardens of Sukra and Menscia, both round about Tripoli. These have long been under cultivation and, hence, have an abundant formation of humus. The fertility and productivity of the ground are famous. In the soil there is some coarse element, and a great deal of very fine clay. The carbonates, lime prevailing, amount to 43 per cent, a very high figure. A sandy ground near Zanzur had less of humus, because but little cultivated, fewer coarse elements and fewer carbonates; it averaged only 9

COMPARATIVE SOIL COMPONENTS OF CYRENAICA.

Properties of Soil.	Derna.	Gasr ei Habr.	Fount of Apollo.	Mergi.	Cyrene.	Silene.	Benghazi.
Sand	....	....	....	44.16	60.12	66.80	....
Clay	....	....	....	52.72	14.36	30.81	....
Lime	....	....	....	2.11	25.47	1.40	....
Humus	....	....	....	1.01	0.05	0.99	....
Organic Substance	7.67	5.21	6.80	8.30	7.70	7.51	3.90
Calcium Carbonate	54.37	1.43	1.14	25.68	1.14	1.40	1.00
Phosphoric Anhydrode	0.79	0.14	0.14	0.16	0.19	0.11	0.20
Sulphuric Anhydrode	0.26	0.06	0.07	0.10	0.04	0.05	0.05
Potash	0.34	0.63	0.47	0.14	0.28	0.83	0.71

Compiled by Jewish Territorial Organization of London, 1909.

per cent. Other analyses of sand at about thirty miles to the eastward of Tripoli, distinctly desert sands, uncultivated, produced a still lower figure, but the elements were the same. From new analyses made at various points, it may be deduced that the lime diminishes in proportion to the distance from the sea and increases as the region of Gebel is neared. The explanation is simple:

"The lime is brought by the sea breeze from the coast dunes and by the land winds from the calcareous hills of Gebel, of Tarhuna, of Msellata, etc. But in contact with the hard quartz grains that predominate in the formation of the sand dunes, the lime is rapidly drifted into heaps by the wide sweep of the wind over the immense plain. The lime being softer, is so completely pulverized that it is disseminated in the air as an impalpable powder. On the other hand, in the cultivated places the wind does not operate to the degree of injuring the soil, but only to the extent of bringing to it new material, and the lime brought thither adheres to the soil and there remains to assist in the fruition of the plant. Cultivation also has its effect upon the relative proportion of the component elements. In fact, the pebbles and coarser grains do not reach the cultivated ground. But, to reiterate, there is no distinctive mineralogical diversity between the cultivated sands and those of the aforesaid 'desert' outside of Tripoli.

"They who would apply to Cyrenaica the same cultural rules as are applicable to the plain of Tripolitania would court economic disaster. It would, indeed, be difficult to find two countries relatively so near to one another and yet so profoundly different—different geologically and yet more different morphologically; different in soil, in the distribution and flow of water, in the cultural system.

"Along the coast of Cyrenaica, from Benghazi to Tobruk, the sea water is found to lose its salinity. In fact, it is mixed with fresh water which, from the high plane of Barca descends with force and strikes the sea. The fact is not strange to the geologist. Cyrenaica is a mountain plateau, all fractured and full of caverns where the waters are abyssed. It happens similarly in the environs of Trieste (Austria), where the drinking water is brought from a rich source that has a hidden subterranean outlet to the Adriatic."

The subject thus discussed by Prof. de Regny is not only one of supreme interest to the mediterranean nation that is extending its domains to the north of Africa, but must engage the attention of all who intelligently follow the leading events in the evolution of the world's history. We shall await with interest the further developments of the project here considered.

Manufacture and Treatment of Steel for Guns—I*

An Industry of About Thirty Years Standing

By General L. Cubillo

INTRODUCTORY.

It is about thirty years since steel was definitely adopted by the chief countries of the world for gun construction. The many difficulties presented in the manufacture of large homogeneous masses of steel, and the resistance offered by tradition and routine to every change in industrial processes were the chief causes of the continuation of the use of cast and wrought iron, in the third quarter of the last century, if not for the whole construction, at least for the principal elements of guns. The celebrated American artillerist, Rodman, cast large caliber guns, of cast iron exclusively, and applied, during and after the casting process, his invention of cooling the inside of the gun with water, and of heating the outside in such a manner that the inside was compressed by the outside. By this the maximum tangential resistance of a single tube is attained, and it is then best fitted to oppose the pressure of the powder. The metal used by Rodman in the manufacture of guns was of a quality which has not since been surpassed. The pig iron employed was charcoal and cold blast iron, from ores of the greatest purity, so that the resulting cast iron possessed the best mechanical qualities. The resistance of cast iron guns was certainly increased by the Rodman process, though it was not known exactly by how much, since it is impossible to apply the rules of shrinkage to guns treated as described. But the improvement so obtained was not sufficient for the requirements of the artillery, and cast iron, whether alone or combined with wrought iron or puddled steel, was incapable of withstanding very great pressure. It was certainly possible to fire the guns so constructed with charges larger than those employed in ordinary cast iron guns, but the difference was not great, since a very considerable part of the gun was made of cast iron, the mechanical properties of which are deficient as compared with those of wrought iron and steel. In France and Spain a combination of steel, wrought iron and cast iron was tried, the first metal being employed for that part of the bore where the pressure is greatest, but this combination, which actually produced guns more powerful than those made of cast and wrought iron, was abandoned since, owing to the progress of metallurgical science, the manufacture of steel in large masses had now become possible. The guns made of this triple combination were capable of withstanding a pressure of 2,200 kilometers per square centimeter. It was necessary to use quick-burning powders in them, because the steel tube not being of the total length of the bore, the gun at the cast iron end was much weaker and incapable of withstanding great pressure. It is, therefore, easy to understand why, as soon as it became possible to cast great masses of steel, this metal, with its greatly superior physical and mechanical properties, was exclusively adopted for the construction of large guns. It will always be a distinction, however, for the Krupp works to have been the first to cast great masses of steel, while the Bessemer and open-hearth processes were still unknown to the metallurgists, but the method by which Alfred Krupp achieved his wonderful results is so well known that it need hardly be described here.

I. CONDITIONS OF THE STEEL REQUIRED FOR GUN CONSTRUCTION.

If it were possible to produce a metal at low cost such that it possessed a high elastic limit, and also high tenacity, great ductility, and resistance to the wear produced by the powder gases at great pressure and high temperature, with, moreover, a very high melting point, such a material would undoubtedly be the most suitable for the manufacture of guns. The very great pressure which the material must withstand is not, it is true, of great duration or of great frequency in large and medium-sized guns; but it is necessary to take into consideration the fact that what causes this enormous pressure is the highly heated gases, which exercise both a physical and, in a certain portion of the bore of the gun, a chemical action on the metal. As has already been said, steel has been adopted as the only material suitable for guns. But steel offers so great a variety of types, that it becomes necessary to select from among these one which possesses in the highest degree the conditions already laid down. If the steel is ordinary carbon steel, its high elastic limit is accompanied by a high tenacity and less ductility than that which accompanies a metal of smaller elastic limit and tenacity. The resistance of the former metal to dynamic stresses will be less than that of the second, and its melting point will also be lower. The gun makers have universally adopted a metal between the dead soft and the hard steels, namely, an iron-carbon alloy, tending rather toward mildness, due specially to its high melting point. This last property is now very important on account of the use of the modern smokeless powders, and especially

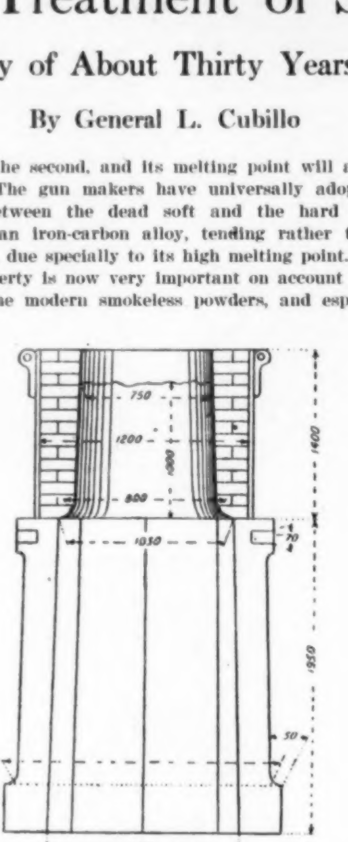


Fig. 1.—Ingot Mold.

the nitro-glycerine powders. The high combustion temperature of these powders, and the incomplete obturation of the driving band of the projectile at the commencement of its travel in the bore of the gun, is the origin of what is called erosion in the bore. The modern experiments of Vieille and some others made at South Bethlehem, not to mention the earlier ones made by Sir Andrew Noble, have demonstrated without doubt that the mild steels are better able to withstand the effects of erosion, because, among other properties, they possess melting points higher than those of the hard steels.

An ordinary carbon steel for guns has about 0.5 per cent of carbon, and its place in the iron-carbon solution is in the series of the metals called steels, having a carbon percentage of less than 2 per cent. The characteristic of this series is that it is not eutectic at its freezing point, and that it presents a similar phenomenon in the subsequent cooling, when it arrives at the point *Ar* in the cooling curve. All this refers only to the ordinary carbon steel. The ternary alloy of iron-carbon and nickel or the quaternary alloy of iron with carbon chromium and nickel is employed in the manufacture of medium and small guns only, because the cost of such an alloy would be prohibitive in the construction of the larger ones, especially now that the principle of uniformity of caliber has been adopted by all the navies of the world. It must be said, however, that the *A* and *B* tubes for the great 16-inch experimental gun manufactured in the United States are of nickel steel. In adopting this alloy for the construction of guns it has been necessary to diminish the percentage of carbon, because if it reached that of ordinary carbon steel with percentages of 2.5 to 3.5 per cent of nickel the steel would be very hard, that is, it would be what Mr. Guillet calls "martensitic steel."

Mechanical Tests.—It is not necessary to give here a complete table of the specifications for gun steel as required by the armies and navies of the European and American powers. In all the specifications two different kinds of mechanical tests are required; in the one case, that of continuous and progressive tension up to the yield point, together with the measurement of the elongation after breaking; while the other test consists in subjecting the test piece to a certain number of impacts according to details and conditions fully specified, or, perhaps, to some bending test, equally fully specified. If the steel has been manufactured from pure materials, such as the best Swedish pig iron and from scrap from the puddling of the best hematite pig iron, and if it has been carefully cast, forged, annealed, hardened and tempered, the tensile tests are quite sufficient in the author's opinion; while the close examination of the forgings during machining will, conjointly with the tensile tests, also convey a good idea of the quality of the metal, so that the impact or bending tests can be dispensed with. But perhaps it may happen that the best treatment has not been properly conducted, and that the metal which withstands the tensile tests may fail in the impact tests. The latter are those which give a really good idea of the brittleness of the metal. Many years ago these mechanical and bending tests were introduced into the specifications for ascertaining the presence of phosphorus in the steel. It is possible that a metal with a high percentage of this metalloid may give satisfactory results in the static tensile tests, and that the yield point and the ductility may be very good; but this steel would certainly withstand far fewer impacts than a very pure steel. Indeed the tests, which a metal suitable for gun construction must undergo, must produce stresses similar to those caused in the gun by the power gases. This metal, when the gun is composed of a single tube, as is generally the case in mountain guns, passes, in an infinitesimal space of time, from the state of repose to a strain of two thirds at least of its elastic limit of static tension; and when the gun is a composite tube the concentric layers of some of its elements pass in an equally short space of time from a state of compressive stress to another of tensile stress, both of which are opposite states of stress of considerable importance. Taking into consideration both the opposite stresses to which the elements of the guns are subjected, before and under fire, perhaps the best mechanical test for gun steel would be that of alternating stresses with considerable variation, these stresses being repeated a certain number of times in harmony with the rounds fired by the guns. The shock tests are now universally accepted, as has been said, in order to ascertain the fragility of the metal. The resolutions of the last congress of "Les Methodes d'Essai des Materiels" assembled at Copenhagen recommend a shock test with test pieces, together with a slight nick in one of the long sides of the piece. Certainly this test must be adopted as one of the means of ascertaining the good quality of gun steel.

II. MELTING OF THE STEEL.

Of all the processes employed in the melting of steel the only ones used in the manufacture of gun steel have been the crucible and the open-hearth processes. The first process was naturally employed before the introduction of the open-hearth method, and for some time afterward; but the latter has now superseded the crucible process, except at the Krupp works.

Mention has already been made of the great claims possessed by this firm as the pioneers in casting, by the crucible process, great masses of steel intended for gun construction. Credit must also be extended to the English firms of Firth, Vickers and Whitworth, which also employed their energies in the improvement of this manufacture. The firm of Krupp has always claimed that the crucible process offers the best guarantee for a sound metal for gun construction. Undoubtedly it is possible to obtain by it a metal of greater purity with regard to phosphorus and sulphur than by any other process, if the material charged in the crucibles is wrought iron from hematite pig iron. The metal obtained in this case will be the best possible steel, and it will not contain occluded gases; or at all events in very small proportion. If the metal charged in the crucibles is free from oxides, the only gases dissolved in the steel will be those which have passed through the walls of the crucibles.

In the author's opinion steel made by the crucible process must lack homogeneity, because it is almost impossible that the composition of the charge of all the crucibles will be the same. It is also impossible to secure uniformity of composition in the ingot mold bearing in mind segregation. The only way of secur

* Reproduced from *The Engineer*.

ing homogeneity by this process would be to teem the crucibles first into a hot ladle, and then into the ingot mold. The principal reason for this lack of homogeneity lies in the impossibility of analyzing all the puddled bars which form the charge of the crucibles, classification by the eye being very uncertain. Therefore, in the author's opinion, a massive ingot of steel cast by the crucible process is more heterogeneous than a similar ingot cast by the open-hearth process. The open-hearth acid process is generally employed for the casting of great masses of steel. The basic process can, of course, be employed, provided the materials charged are acid; and there is no difficulty in obtaining by the open-hearth process, that is, by the dissolution in a cast iron bath of a certain quantity of wrought iron or steel, a very pure metal, such as is required in the construction of guns. All depends on the purity of the pig iron and scrap charged.

It is the constant practice of all the steel works where steel for gun construction is regularly made to employ Swedish pig iron of the best quality, the phosphorus being as low as 0.025 per cent, and the sulphur lower than this amount; and for the scrap, puddled balls or bars from the best hematite pig irons.

By puddling this pig it is possible to obtain a product with phosphorus and sulphur as low as 0.001 per cent, and as furnaces of 50 or 60 tons capacity are now very common, and as for the casting of the largest element of the new great guns it is not necessary to have ingots of more than 100 or 120 tons, the result is that it is not very difficult to obtain a great uniformity of the metal by this process. The conditions of open-hearth working permit of working two or three furnaces so uniformly that, at the time of casting, the metal of the two or three furnaces will be perfectly similar. The steel is much exposed to the oxidation of the furnace gases, always in contact with the bath; and to this action is added that of the iron ore incorporated for oxidizing in a rapid and energetic manner the silicon and carbon in excess of that required in the steel. There are many means of diminishing the oxidation of the bath; one of them is to prepare the charge by putting in the furnace the greatest possible amount of scrap, with the smallest quantity of carbon, and conducting the refining process by the furnace gases only without the addition of any iron ore. This particular method of working is extraordinarily slow; first, because, as the materials, both pig iron and slag, are charged at once and cold, the mixed bath is very low in carbon and its melting point very high. It therefore requires more time for melting it than if the charge had been composed of equal parts of pig iron and scrap. Secondly, because the oxidation of the carbon by the gases is not so efficacious as that by the iron ore, this being more in contact with the bath and the former acting only on the surface. Operating in this way the final steel is almost free of oxides, and in order entirely to eliminate them additions are made, at the end, of certain iron alloys, such as ferro-manganese and ferro-silicon, which by their action upon the bath reduce the iron oxides dissolved in it. This addition is the more required when the charge has been of equal parts of pig iron and scrap. The percentage of carbon of such a charge at the fusion or melting time will be very high, and it is not possible to oxidize the excess carbon to the point required in the artillery steel by the action of the gases only, and it is almost imperative to employ the iron ore for accelerating the oxidation of the carbon.

Fusion at Trubia of the Ordinary Carbon Steel for Guns.—The steel works at Trubia comprise two furnaces—one of large capacity, capable of taking charges up to 54 tons, and the other of 16 tons. Therefore, it is possible, working with the two furnaces to obtain an ingot of 64 tons. The furnaces were supplied by Messrs. Frederick Siemens, of London, and are of the usual design. They are situated in a straight line, with a very commodious working platform, and are served by an electric charging crane, of the well-known Wellman type. For the service of the casting shop there are two overhead electric travelling cranes, one of 75 tons capacity, with one motor only of 30 horse-power, and the other is a Niles 50-ton capacity crane, worked by four motors of 130 total horse-power. The second crane, of course, has been more recently installed than the first. In the fusion of the ordinary carbon steel for guns, the materials employed are Swedish pig iron and puddled ball from Bilbao hematite pig iron. In order to convey an idea of the operation a heat in the 16-ton furnace will be described.

The furnace was charged with 7.5 tons of Swedish pig iron and 9 tons of puddled ball from Bilbao hematite. These materials were charged straight into the furnace, the first charged being the pig iron. At 9.2 A. M. the charge was commenced, and melted at 2.40 P. M. The first iron ore addition of 60 kilogrammes weight was made at 2.50 P. M., and another of the same weight at 3.15 P. M., followed by another of 50 kilogrammes at 3.35 P. M. During the melting period and the following forty-five minutes nearly all the silicon was oxidized. Some minutes after the third iron ore addition, the ebullition of the bath commenced, which evidently proved that the oxidation of the carbon was energetically proceeding. The iron ore additions followed from time to time as the state of the bath indicated the necessity. The operation was conducted with the air valve closed as much as possible, so that the metal should not become cold, nor become oxidized. The total additions of iron ore amounted to 350 kilogrammes. At 6.25 P. M. the calorimetric analysis of the small sample taken from the bath and very slowly cooled gave a percentage of carbon of 0.52 per cent, and as the quantity required in the steel must be between 0.45 and 0.55 it was decided to tap the furnace, making previously the suitable additions of alloys. These were ferro-manganese and ferro-silicon, putting 124 kilogrammes of the first and 99 kilogrammes of the second. The percentages required in the metal were 0.55 to 0.65 per cent of manganese and 0.15 per cent of silicon. This percentage is quite sufficient for obtaining a metal totally free from side and central cavities, except those at the top of the ingot and the pipe. The metal is poured into a Wellman ladle, previously well heated by producer-gas. The ladle is then transported by the 50-ton electric crane to the casting pit, where the metal is poured into the mold.

Ingot Mold.—This is of cast iron, with a wash of refractory material, intended to retard the cooling of the metal at the top, keeping it fluid as long as possible, so that it may fill the space left vacant by the contraction of the metal in the rest of the mold. The mold, both outside and inside, has the form of a truncated pyramid—see Fig. 1. The sides of the inside pyramid, instead of being plane are curved surfaces joined to one another by rounding the edges. It seems natural that, since the elements of guns are cylindrical, the ingot molds should also be of cylindrical form inside, and since also the steel, as it solidifies, crystallizes in crystals whose axes are normal to the surface of the mold, the cylindrical form should be the best for obtaining good sound ingots without cracks. The reverse is what happens. The ingots cast in circular metal molds have always a deep longitudinal crack, and thus are incapable of subsequent forging. In order to avoid the occurrence of cracks during solidification and subsequent cooling on the outside surface of the ingots, they are sometimes cast in refractory molds. But though no cracks occur in ingots cast in such molds, the long time spent in the cooling of a large ingot, cast in such manner, produces a very coarse crystalline texture, almost impossible of being changed to the proper texture during the forging. The experience at Trubia with 40-ton ingots cast in refractory molds has been totally adverse to their use as substitutes for metal molds for the part of the ingot really utilized. When this is completely solidified and almost cold on its outside, it is taken out of the mold and is covered with ashes until it is completely cool. After this it is carefully examined for cracks, which are dealt with by the pneumatic hammer. As it is not an easy matter to get rid of them entirely by these means, the ingot is sent to the forging shop, where it is subjected to a slight preliminary forging, just sufficient to give it a cylindrical form. Any cracks which were not visible in the preliminary examination then appear, and are taken out in the lathe. Some very good metal is thereby lost, but in the finishing up of the forging no cracks appear, and it is possible to finish the pieces with the least possible excess in the dimensions required for the hardening.

Before describing the forging, it may be mentioned that, about half way through casting, operations are suspended for an instant, while a very small ingot is cast from the ladle. This is intended for the full analysis of the metal, and for forging a test piece for a preliminary tensile test. In order to study the segregation phenomena in the unfinished steel, the head from a 16-ton ingot was divided through its vertical axis. One of the halves of this head is represented in Fig. 2. From it were taken the samples for analyzing the carbon, manganese, phosphorus and silicon. The samples were taken only in one half of the head, because it was presumed that the symmetrical parts of the other half must have the same composition, as the conditions of cooling were equal for both halves. The small ingot taken during the casting operation, which, owing to its very small dimensions, is free from the phenomena of segregation, and fairly represents the composition of the steel in the ladle—where it is supposed to be completely homogeneous—gave on analysis 0.56 per cent of carbon and 0.57 per cent of manganese. On comparing these percentages with those of the samples it is observed at once that there is not a very great difference between the samples taken at the circumference of the head and those of the small

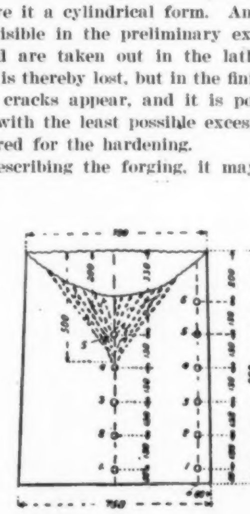


Fig. 2.—Portion of Ingot Sampled (See Table).

No.	Carbon. Per cent.	Manganese. Per cent.	Silicon. Per cent.	Phosphorus. Per cent.
Center.				
1	0.565	0.525	0.187	0.024
2	0.672	0.610	0.210	0.029
3	1.176	0.620	0.230	0.029
4	1.607	0.620	0.261	0.036
5	2.484	0.610	0.284	0.049
Outside Surface.				
1	0.564	0.595	0.187	0.021
2	0.463	0.580	0.187	0.018
3	0.565	0.570	0.187	0.017
4	0.427	0.575	0.187	0.017
5	0.443	0.565	0.187	0.018
6	0.497	0.585	0.163	0.019

Analyses of Small Ingot Taken During Pouring.

	Per cent.
Carbon	0.562
Manganese	0.766

ingot. But the difference is very great in the samples taken in the center of the head. Here, segregation phenomena are in evidence, especially with regard to carbon. It is observed that sample No. 1, from the bottom of the head, has the same quantitative composition as the metal of the small ingot, but in samples Nos. 2, 3, 4 and 5 the percentage of carbon increases gradually, being in sample No. 5 four times greater than in sample No. 1. The manganese increases also, but less so; the silicon more than the manganese, while the phosphorus in sample No. 5 is double that of No. 1. The layer of steel, in contact with the ingot mold, represents very nearly the composition of the metal; in fact, the percentage of the metalloids is less. The layer successively cooling from the outside yields to the inside layers a certain part of its metalloids until the central part of the ingot is reached, which, being the last to solidify and cool, is therefore richer in foreign elements. As the ingot mold is not closed, and is not in the form of a symmetrical cube, the segregation phenomena do not occur in the ordinary ingot mold in the manner described by Howe in his classical book, "Iron, Steel and Other Alloys," as the "Onion type" of freezing. If the mold is a perfect cube, and the action of the gravity be assumed to be counterbalanced, the segregation phenomena should occur in a completely regular manner, in layers parallel to the sides, and the metal richer in foreign elements will be exactly in the center of the figure. In the casting of large ingots the segregation phenomena must occur as described, because the top of the ingot is the last to cool, especially if, as in the case at Trubia and elsewhere, the head of the mold is of refractory material, which contributes, to a great extent, in keeping the metal fluid longer than if this part of the mold were of metal.

About twenty years ago Brustlein explained, in a report to the "Commission des Methodes d'Essai des Materiaux" in 1892, the lack of homogeneity of steel ingots and segregation phenomena in a manner very similar to that already explained in this paper, but without the aid of chemical analysis. His views as to segregation phenomena are in perfect accord with the manner of solidifying the iron-carbon solutions, as Roozeboom has explained in his diagram.

Applying their theories to the solidifying of steel ingots for gun tubes, it is easy to explain why the percentage of carbon increases from the outside layer in contact with the walls of the mold to the center of the ingot, culminating in the greater amount of carbon and of the other foreign elements in the upper and central part of the ingot which is the last to set.

Fluid Compression.—Fluid compression consists, as everyone knows, in applying pressure to the steel while still fluid or semi-fluid. The process has acquired considerable development, and is extended to ingots of common steels, whereas it was at first only applied to ingots intended for the manufacture of guns or for the large shafts of ships. The older fluid compression method is that of Whitworth, whose patent was taken in 1866, the chief object of which was to obtain cast steel ingots free from cavities. The Whitworth process is undoubtedly a very good one, and, considered econom-

ically, it offers great advantages, but in practice not all the advantages of fluid compression are obtained. In one of the most important French steel works, where this process is applied to the ingots intended for the construction of guns, the author has had occasion to examine some of them and has found that the pipe at the top does not entirely disappear.

In order to demonstrate that the Whitworth fluid compression process gives homogeneous ingots—that is, ingots free from segregation—it would be necessary to demonstrate it practically by dividing a large ingot longitudinally, and taking many samples for analysis, from all parts, or at least in the upper third. It is certain that in present-day practice, with the judicious use of deoxidizing alloys in the furnace such as ferro-manganese and ferro-silicon, and perhaps with a very slight addition of aluminium during the casting operation, it is possible to obtain ingots free from cavities, except at the very top, in the central part, as is seen in the head of a 16-ton ingot, represented in Fig. 2. In this, as in all similar ingots, a very sound and homogeneous—70 per cent—total mass was obtained. In favor of fluid compression it may be said that it causes the disappearance of the deep cracks, especially in the bottom of the ingot. Perhaps this is to be attributed rather to the lining of the inside of the ingot mold with refractory material. The cracks are always a serious defect, and sometimes, if ingot molds of polygonal section without rounded corners are employed, and the block, after forging, is put on the lathe, they appear as dark lines along the total length of the piece, which correspond to the angles of the ingot. Certainly, in many cases the turnings do not break off when the tool cuts across the dark lines, but all the same the appearance of such lines does not suggest a very good quality of metal.

With regard to the improvement of the mechanical properties by fluid compression, the author must say that it is not very evident to him. Perhaps it is assumed that fluid compression during the last period of the process, when the metal is in a semi-fluid state and almost set, confers an effect similar to forging. In Whitworth fluid compression, after the expulsion of the gases, the press does not cause any deformation in the ingot, and there cannot be forging without deformation. Some years ago a new fluid compression process was patented by Messrs. Robinson and Rodgers, of Sheffield, in conjunction with Mr. Illingworth, of New York. This process has been described by Mr. A. J. Capron.[1] The advantages derived are that absolutely sound ingots are obtained free from cavities and pipe, so that the whole of the ingot can be utilized, without any waste. As it is possible to watch, during the compression, the top of the ingot and the setting of the liquated part of the steel, a great improvement in the quality of the metal can be obtained. The ingots are poured in the same place as they are compressed. The plant is very simple and economical, and can be operated by men without special training, and, the ingot molds being in halves, the top and bottom sections are equal, which facilitates the rolling.

Another compression fluid process, which has become very well known and accepted during the last years, and is widely adopted in France, England, and Germany, is that patented by Mr. Harmet, of St. Etienne, which has also been fully described by him to the Iron and Steel Institute.[2]

In concluding this part of the paper, the author would repeat that, in his opinion, the principal advantage to be derived from fluid compression lies in its economical aspect. When casting under ordinary conditions, it is possible to utilize from 75 to 80 per cent of the ingot, while with compression it is possible to reach 90 per cent.

To be continued.

Appropriations for Military Aeronautics in Germany

The Berlin daily papers announce that the new bill for navy appropriations which the Reichstag voted not long since provides a credit of $400,000 for the purchase of ground for hangars for airships which will be used in connection with the navy. The first move in this direction is the purchase by the Navy Department of a large tract of ground at Neumunster (Holstein). It is also stated that $500,000 is to be allotted for the purchase of airships, and the first of these will be the "Victoria-Louise." The navy is also to begin the use of hydroplanes very shortly. At the Johannisthal station there are a number officers and engineers of the marine in training as pilots for aeroplanes and airships.

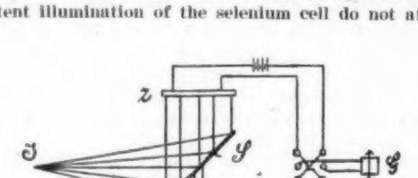
[1] *Journal* of the Iron and Steel Institute, 1906, No. I, page 28.

[2] *Journal* of the Iron and Steel Institute, 1902, No. II, page 146.

New Selenium Cells*

Of the various forms in which selenium cells have been constructed the most efficient is Bidwell's wire cell, which consequently is employed almost exclusively, although its construction presents certain well-known difficulties. This cell is made by winding two wires close together on an insulating core, and filling with selenium the narrow interstice between the wires. The commercial Bidwell cells are quite sensitive to light, but they possess considerable electrical inertia. They also have high resistance, because the insecurity of position of the wires imposes a limit to the narrowness of the interval between them, and because the dimensions of the cell are limited by difficulties of construction which increase rapidly with the size.

In my attempt to improve the selenium cell I first endeavored to ascertain how the electrical inertia could be diminished. For this purpose I constructed the apparatus indicated in the diagram, in which a selenium cell *Z* is illuminated intermittently by light emitted by the source *J* and reflected by the rotating mirror *S*. A commutator *K* is connected with the axis of the mirror in such a manner that the current flows through the galvanometer in the positive direction, while the selenium cell is illuminated and in the negative direction when the cell is in darkness. The moment of inertia of the suspended coil must be so large that the fluctuations impressed upon the current by the intermittent illumination of the selenium cell do not affect



the pointer of the galvanometer sufficiently to make the reading difficult.

In these conditions the deflection of the galvanometer measures the difference between the currents flowing through the selenium cell in the periods of illumination and of darkness, and the deflections obtained with different cells of approximately equal resistance and sensitiveness indicate the difference in electric inertia. In this way it was possible to proceed systematically with the construction of experimental cells and to prove that the electric inertia depends largely on the manner in which the selenium is heated.

After many laborious experiments I succeeded in constructing a selenium cell which almost instantaneously assumes the resistance corresponding to any degree of illumination, so that the so-called "creeping" of the current is almost entirely eliminated.

When cells of the older types are suddenly illuminated several minutes elapse, as a rule, before the resistance which corresponds to the illumination is attained. In the new cells the change in resistance is effected in an instant. The voltage limit of the old cells, furthermore, is very small, but the new cells can carry a load of several hundred volts without injury, and without the employment of auxiliary resistances.

The new cells possess the maximum sensitiveness to light, owing to the very advantageous distribution of the selenium. The resistance is exceedingly low because the distance between the electrodes is reduced to a minimum. The resistance can be further diminished by increasing the dimensions. Cells of 12 inches diameter have already been constructed.

The new cells show very little electric inertia with decreasing illumination and practically none with increasing illumination. Deterioration due to chemical change is entirely prevented by the employment of platinum electrodes and the complete exclusion of air, and the capacity to withstand high voltage exceeds all possible requirements. Cautious experimenting with galvanic batteries is consequently unnecessary, and the danger of short circuits and the destruction of valuable instruments is entirely eliminated. Even sparks produced by the employment of excessively high voltages do not seriously injure the cell, but at the most, merely destroy the usefulness of minute portions of the sensitive layer.

In the new cells a thin coating of metal deposited on an insulating base is divided by fine scratches into two or more parts, which serve as electrodes. The metal is then covered with pulverized selenium which, when heated, melts and fills the scratches. This construction possesses the advantages that the distance between the electrodes can be reduced to a minimum, and that the size and shape of the cell can be varied indefinitely. The circular form has been chosen as the normal, as it is the best adapted to most uses. The new cells are patented.

* Paul Jenisch in *Elektrotechnische Zeitschrift.*

That Aviation May Have Scientific Basis.—The Massachusetts Institute of Technology announces special lectures on aeronautics, the first series of which will be given the coming school year. The lecturer is to be A. A. Merrill, sometime secretary of the Boston Scientific Society, for seven years and more an investigator in the laboratories of the Institute and in the opinion of those competent to judge, one of the strongest men in the country in the theory of this department on knowledge. In an informal talk about the new work, Prof. E. F. Miller, head of the department of mechanical, stated that already the Institute has done a great deal in investigation of technical factors to aviation. For many years it has had in operation a "blowing tube" three feet square, through which a current of air may be forced at velocities up to ten or twelve miles an hour. This has been used by Mr. Merrill and by the students in this work in carrying on investigations of the lift and drift of surfaces of different sizes and shapes under different velocities of wind.

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